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Aggregate Resources Inventory of Sydenham Township Grey County Southern Ontario

By Staff of the Engineering and Terrain Geology Section, Ontario Geological Survey

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Aggregate Resources Inventory of Sydenham Township Grey County

by
Staff[1] of the Engineering and Terrain Geology Section

1. Project supervisor: Dale W. Scott; field work and report by I. Szoke; compilation and drafting by staff of the Aggregate Assessment Office. The Mineral Resources Staff of Owen Sound District and Southwestern Region of the Ministry of Natural Resources assisted in the collection of data, field checking and review of this report.

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Abstract

This report includes both an inventory and evaluation of sand and gravel, as well as bedrock resources, in Sydenham Township. The report is part of the Aggregate Resources Inventory Program for townships and municipalities designated under the Pits and Quarries Control Act.

There are few surficial sand and gravel deposits in Sydenham Township. The deposits contain very limited reserves of aggregate and are best suited for low-specification uses. The larger deposits have been selected only at the secondary level of significance because of their inherent quality and quantity limitations. The possible resources of sand and gravel remaining will be insufficient for local needs in the future, and will require augmentation from other sources. Care should be taken to ensure the proper utilization of the remaining resources.

There are several bedrock formations which underlie the township. Possible aggregate resources derived from bedrock are available from the Amabel Formation. Dolostone from the Amabel Formation is suitable for the production of crushed stone and other industrial mineral products. Possible resources in two Selected Bedrock Resource Areas are 4650 million tons (4200 million tonnes).

Selected Resource Areas are not intended to be permanent, single land use units which must be incorporated in an official planning document. They represent areas in which a major resource is known to exist. Such Resource Areas may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

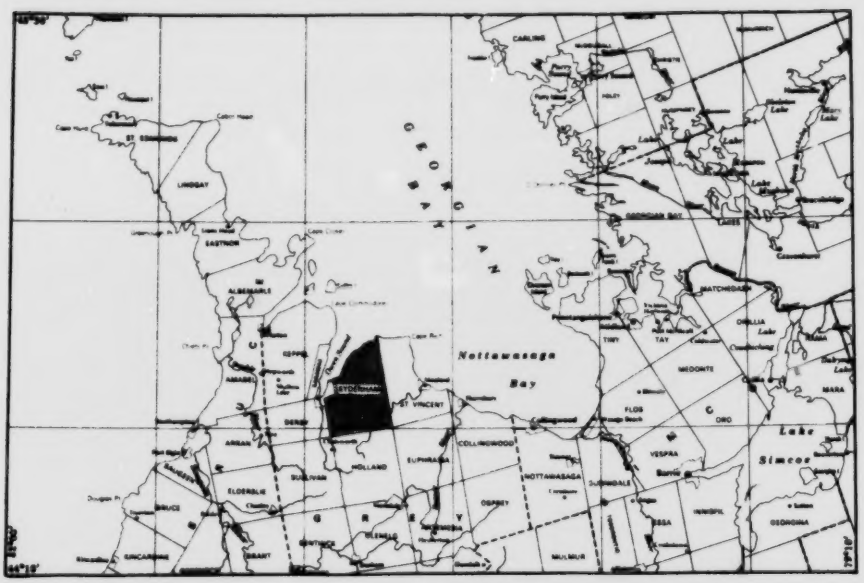


Figure 1. Key Map Showing the Location of Sydenham Township, Scale 1:1 800 000.

Introduction

Mineral aggregates, which include bedrock-derived crushed stone as well as naturally formed sand and gravel, constitute the major raw material in Ontario's road-building and construction industries. Very large amounts of these materials are used each year throughout the Province. For example, in 1982, the total tonnage of mineral aggregates extracted was 101 million tons (92 million tonnes), greater than that of any other metallic or nonmetallic commodity mined in the Province (Ontario Ministry of Natural Resources 1983).

Although mineral aggregate deposits are plentiful in Ontario, they are fixed-location, nonrenewable resources which can be exploited only in those areas where they occur. Mineral aggregates are characterized by their high bulk and low unit value so that the economic value of a deposit is a function of its proximity to a market area as well as its quality and size. The potential for extractive development is usually greatest in urban fringe areas where land use competition is extreme. For these reasons the availability of adequate resources for future development is now being threatened in some areas.

Comprehensive planning and resource management strategies are required to make the best use of available resources, especially in those areas experiencing rapid development. Such strategies must be based on a sound knowledge of the total mineral aggregate resource base at both local and regional levels. The purpose of the Aggregate Resources Inventory is to provide the basic geological information required to include potential mineral aggregate resource areas in planning strategies and official plans. The reports should form the basis for discussion on those areas best suited for possible extraction. The aim is to assist decision-makers in protecting the public well-being by ensuring that adequate resources of mineral aggregate remain available for future use.

This report is a technical background document, based for the most part on geological information and interpretation. It has been designed as a component of the total planning process and should be used in conjunction with other planning considerations, to ensure the best use of a municipality's resources.

The report includes an assessment of sand and gravel resources as well as a discussion on the potential of bedrock-derived aggregate. The most recent information available has been used to prepare the report. As new information becomes available, revisions may be necessary.

Part I — Inventory Methods

FIELD AND OFFICE METHODS

The methods used to prepare the report primarily involve the interpretation of published geological data such as bedrock and surficial geology maps and reports (see References) as well as field examination of potential resource areas. Field methods include the examination of natural and man-made exposures of granular material. Most observations are made at quarries and sand and gravel pits located from records held by the Ontario Ministry of Transportation and Communications, the Ontario Geological Survey, and by Regional and District Offices of the Ontario Ministry of Natural Resources. Observations made at pit sites include estimates of the total face height and the proportion of gravel- and sand-sized fragments in the deposit. Observations are also made of the shape and lithology of the particles. These characteristics are important in estimating the quality and quantity of the aggregate. In areas of limited exposure, test pitting, soil probing, hand augering and geophysical techniques are used to assess subsurface materials. Airphotos at various scales are used to determine the continuity of deposits, especially in areas where information is limited.

Deposits with potential for further extractive development or those where existing data are scarce, are studied in greater detail. Representative layers in these deposits are sampled in 25- to 100- pound (11 to 45 kg) units from existing pit faces or from test pits. The samples are analysed for grain size distribution and in some cases Los Angeles abrasion, absorption, and Magnesium Sulphate soundness tests along with petrographic analyses are performed.

Analyses are performed either in the laboratories of the Soils and Aggregates Section, Engineering Materials Office, Ontario Ministry of Transportation and Communications, or in the Geoscience Laboratories, Geoservices Section, Ontario Geological Survey. In areas of limited subsurface exposure, test holes are drilled and geophysical surveys using hammer seismic equipment are undertaken. The symbols for and locations of sample and test hole sites along with geophysical traverse lines are noted on Map 1.

In the office, the field data are supplemented by pit information on file with the Soils and Aggregates Section of the Ontario Ministry of Transportation and Communications. Data contained in these files include field estimates of the depth, composition and "workability" of deposits as well as laboratory analyses of the physical properties and chemical suitability of the aggregate. Information concerning the development history of the pits and acceptable uses of the aggregate is also recorded. The location, size, and depth of extraction of pits licenced under the Pits and Quarries Control Act are obtained from records held by Regional and District Offices of the Ontario Ministry of Natural Resources. The cooperation of the above-named groups in the compilation of inventory data is gratefully acknowledged.

Water well records, held by the Ontario Ministry of the Environment, are used in some areas to corroborate thickness estimates or to indicate the presence of buried granular material. These records are used in conjunction with other evidence. Topographic maps of the National Topographic System, at a scale of 1:50 000, were used as a compilation base for the field and office data. The information was then transferred to a base map, also at a scale of 1:50 000, prepared by the Cartography Section of the Lands and Waters Group, Ontario Ministry of Natural Resources, for presentation in the report.

RESOURCE TONNAGE CALCULATION TECHNIQUES

SAND AND GRAVEL RESOURCES

Once the interpretative boundaries of the aggregate units have been drawn, quantitative estimates of the possible resources available can be made. Generally, the volume of a deposit can be calculated if its areal extent and average thickness are known or can be estimated. The computation methods used are as follows. First, the area of the deposit, as outlined on the final base map, is calculated in acres. The thickness values used are an approximation of the deposit thickness, based on the face heights of pits developed in the deposit or on subsurface data such as test holes and water well logs. Original tonnage values can then be calculated by multiplying the volume of the deposit by 2500 (the density factor). This factor is approximately the number of tons in a one-foot (0.3 m) thick layer of sand and gravel, one acre (0.4 ha) extent, assuming an average density of 110 pounds per cubic foot (1766 kg per cubic metre).

Tonnage = Area x Thickness x Density Factor

Tonnage calculated in this manner must be considered only as an estimate. Furthermore, such tonnages represent amounts that existed prior to any extraction of material (i.e. original tonnage) (Table 1, Column 4).

The Selected Sand and Gravel Resource Areas in Table 3 are calculated in the following way. Two successive subtractions are made from the total area. Column 3 accounts for the number of acres unavailable because of the presence of permanent cultural features and their associated setback requirements. Column 4 accounts for those areas that have previously been extracted (e.g. wayside and abandoned pits are included in this category). The remaining figure is the area of the deposit currently available for extraction (Column 5). The available area is then multiplied by the estimated deposit thickness and the density factor (Column 5 x Column 6 x 2500) to give an estimate of the sand and gravel tonnage (Column 7) presently available for extractive development and/or resource protection.

Reserve estimates are calculated for deposits of primary significance. Reserve estimates for deposits of secondary and tertiary significance are not calculated in Table 3, however the aggregate potential of these deposits is discussed in the report.

BEDROCK RESOURCES

The method used to calculate resources of bedrock-derived aggregate is much the same as that described above. The areal extent of bedrock formations overlain by less than 50 feet (15 m) of unconsolidated overburden is determined from bedrock geology maps, drift thickness and bedrock topography maps, and from the interpretation of water well records. The

measured extent of such areas is then multiplied by the estimated quarriable thickness of the formation, based on stratigraphic analyses and on estimates of existing quarry faces in the unit. In some cases a standardized estimate of 60 feet (18 m) is used for thickness. Volume estimates are then multiplied by the density factor (the estimated weight in tons of a one-foot (0. 3 m) thick section of rock, one acre (0.4 ha) in extent).

Resources of dolostone are calculated using a density factor of 165 pounds per cubic foot (2649 kg per cubic metre) or 3600 tons per acre (8070 tonnes per hectare). Sandstone resources are calculated using a density estimate of 146 pounds per cubic foot (2344 kg per cubic metre) and shale resources are calculated with a factor of 150 pounds per cubic foot (2408 kg per cubic metre).

UNITS AND DEFINITIONS

Although most of the measurements and other primary data available for resource tonnage calculations are given in Imperial units, Metric units have also been given in the text and on the tables which accompany the report. The Metric equivalent of the data is shown in brackets after or directly below the corresponding Imperial figures. Data are generally rounded off in accordance with the Ontario Metric Practice Guide (Metric Committee 1975).

The tonnage estimates made for sand and gravel deposits are termed possible resources in accordance with terminology of the Ontario Resource Classification Scheme (Robertson 1975, p.7) and with the Association of Professional Engineers of Ontario (1976) (see Glossary, Appendix B).

Part II — Data Presentation and Interpretation

Three maps, each portraying a different aspect of the aggregate resources in the municipality, accompany the report. Map 1, "Distribution of Sand and Gravel Deposits", gives a comprehensive inventory of the sand and gravel resources in the report area. Map 2, "Selected Sand and Gravel Resource Areas", shows those deposits which are considered to represent the largest and/or highest quality resources in the area. Map 3, "Bedrock Resources" shows the distribution of bedrock formations, the thickness of overlying unconsolidated sediments, and identifies the Selected Bedrock Resource Areas.

MAP 1: DISTRIBUTION OF SAND AND GRAVEL DEPOSITS

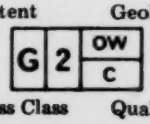
Map 1 is derived from existing surficial geology maps of the area or from airphoto interpretation in areas where surficial mapping is incomplete. The map shows the extent and quality of sand and gravel deposits within the study area and the present level of extractive activity.

On the map, gravel deposits are indicated by dark brown shading while sand deposits are shaded light brown. The present level of extractive activity is also indicated. Those areas which are licenced for extraction under the Pits and Quarries Control Act are shown by a solid outline and identified by a number which refers to the pit descriptions in Table 2. Each description notes the owner, location and licenced acreage of the pit, as well as the estimated face height and percentage gravel. A number of unlicenced pits (abandoned pits or wayside pits operating on demand under authority of a permit) are identified by a numbered dot on Map 1 and described in Table 2.

Map 1 also presents a summary of available information related to the quality of aggregate contained in all the known aggregate deposits in the study area. Much of this information is contained in the symbols which are found on the map. The Deposit Symbol appears for each mapped deposit and summarizes important genetic and textural data. The Texture Symbol is a circular proportional diagram which displays the grain size distribution of the aggregate in areas where bulk samples were taken.

DEPOSIT SYMBOL

The Deposit Symbol is similar to those used in soil mapping and land classification systems commonly in use in North America. The components of the symbol indicate the gravel content, thickness of material, origin (type), and quality limitations for every deposit shown on Map 1. These components are illustrated by the following example:



This symbol identifies an outwash deposit 10 to 20 feet (3 to 6 m) thick containing more than 35 percent gravel. Excess silt and clay may limit uses of the aggregate in the deposit.

The "gravel content" and "thickness class" are basic criteria for distinguishing different deposits. The "gravel content" symbol is an upper case "S" or "G". The "S" indicates that the deposit is generally "sandy" and that gravel-sized aggregate (greater than 4.75 mm) makes up less than 35 percent of the whole deposit. "G" indicates that the deposit contains more than 35 percent gravel.

The "thickness class" indicates a depth range which is related to the potential resource tonnage for each deposit. Four thickness class divisions have been established as shown in the legend for Map 1.

Two smaller sets of letters, divided from each other by a horizontal line, follow the thickness class number. The upper series of letters identifies the geologic deposit type (the types are summarized with respect to their main geologic and extractive characteristics in Appendix C) and the lower series of letters identifies the main quality limitations that may be present in the deposit as discussed in the next section.

TEXTURE SYMBOL

The Texture Symbol provides a more detailed assessment of the grain size distribution in deposits where samples were taken for analysis during field study. The information from which these symbols are derived has been plotted in grain size distribution graphs. The relative amounts of gravel, sand, and silt and clay in the sampled material are shown graphically by the subdivision of a circle into proportional segments. The following example shows a hypothetical sample consisting of 30 percent gravel, 60 percent sand, and 10 percent silt and clay:

Test hole locations are shown on Map 1 by a solid drill hole symbol. Geophysics lines are shown on the map by a line symbol.

MAP 2: SELECTED SAND AND GRAVEL RESOURCE AREAS

Map 2 is an interpretative map derived from an evaluation of the deposits shown on Map 1. The deposits identified on Map 2 are those which are considered to be important in ensuring an adequate resource base for the future.

All the selected sand and gravel resource areas are first delineated by geological boundaries and then classified into three levels of significance: primary; secondary; and tertiary. Each area of primary significance is assessed as to its probable relative value as a resource in the municipality and is given a deposit number which denotes its ranking order. All such deposits are shown by dark shading on Map 2.

Deposits of secondary significance are not ranked numerically in this report, but are indicated by light red shading on Map 2. Such deposits are believed to contain significant amounts of sand and gravel. Al-

though deposits of secondary significance are not considered to be the "best" resources in the report area, they may contain large quanitities of sand and gravel and should be considered as part of the aggregate supply of the area.

Areas of tertiary significance are outlined on the map by a solid line but have no shading. They are not considered to be important resource areas because of their low available resources, or because of possible difficulties in extraction. Such areas may be useful for local needs but are unlikely to support large-scale development.

Selected Sand and Gravel Resource Areas of primary significance are not permanent, single, land use units which must be incorporated in an official planning document. They represent areas in which a major resource is known to exist. Such Resource Areas may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

The process by which deposits are evaluated and selected involves the consideration of two sets of criteria. The main selection criteria are site specific, related to the characteristics of individual deposits. Factors such as deposit size, aggregate quality, and deposit location and setting are considered in the selection of those deposits best suited for extractive development. A second set of criteria involves the assessment of local aggregate resources in relation to the quality, quantity, and distribution of resources in the region in which the report area is located. The intent of such a process of evaluation is to ensure the continuing availability of sufficient resources to meet possible future demands.

SITE SPECIFIC CRITERIA

Deposit Size

Ideally, selected deposits should contain available sand and gravel resources large enough to support a commercial pit operation using a stationary or portable processing plant. In practice, much smaller deposits may be of significant value depending on the overall reserves in the rest of the municipality. Generally, deposits in Class 1, i.e. those thicker than 20 feet (6 m), and containing more than 35 percent gravel are considered to be most favourable for commercial development. Thinner deposits may be valuable in municipalities with low total resources.

Aggregate Quality

The limitations of natural aggregates for various uses result from variations in the litholgy of the particles composing the deposit, and from variations in the size distribution of these particles.

Four indicators of the quality of aggregate may be included in the symbol for each deposit on Map 1. They are: gravel content (G or S); fines (C); oversize (O); and lithology (L).

Three of the indicators deal with grain size distribution. The gravel content (G or S) indicates the suitability of aggregate for various uses. Deposits containing at least 35 percent gravel in addition to a minimum of 20 percent material greater than the 26.5 mm sieve are considered to be the most favourable extractive sites, since this content is the minimum from which crushed products can be economically produced.

Excess fines (high silt and clay content) may severely limit the potential use of a deposit. Fines content in excess of 10 percent may impede drainage in road sub-base aggregate and render it more susceptible to the effects of frost action. In asphalt aggregate, excess fines hinder the bonding of particles. Deposits known to have a high fines content are indicated by a "C" in the quality portion of the Deposit Symbol.

Deposits containing more than 20 percent oversize material (greater than 4 inches (10 cm) in diameter) may also have use limitations. The oversize component is unacceptable for all concrete aggregate and for road-building aggregate, so it must be either crushed or removed during processing. Deposits known to have an appreciable oversize component are indicated by an "O" in the quality portion of the Deposit Symbol.

The other indicator of the quality of an aggregate is lithology. Just as the unique physical and chemical properties of bedrock types determine their value for use as crushed rock, so do various lithologies of particles in a sand and gravel deposit determine its suitability for various uses. The presence of objectionable lithologies such as chert, siltstone, and shale, even in relatively small amounts, can result in a reduction in the quality of an aggregate, especially for high quality uses such as concrete and asphalt. Similarly, highly weathered, very porous and friable rock can restrict the quality of an aggregate. Deposits known to contain objectionable lithologies are indicated by an "L" in the quality component of the Deposit Symbol.

If the Deposit Symbol indicates either "C", "O", or "L" or any combination, the quality of the deposit is considered to be reduced for some uses of the aggregate. No attempt has been made to quantify the degree of limitation imposed. Assessment of the four indicators is made from published data, from data contained in files of both the Ontario Ministry of Transportation and Communications and the Engineering and Terrain Geology Section of the Ontario Geological Survey, and from field observations.

Analyses of unprocessed samples obtained from test holes, pits or sample sites have been plotted on grain size distribution graphs. On the graphs are the gradation specification envelopes for Ontario Ministry of Transportation and Communications' products: Granular Base Course A, B and C; Hot-Laid Asphaltic Sand Nos. 1,2,3,4, and 8; and concrete sand. By plotting the gradation curves with respect to the specification envelopes, it can be determined how well the unprocessed sampled material meets the criteria for each product.

Location and Setting

The location and setting of a resource area has a direct influence on its value for possible extraction. The evaluation of a deposit's setting is made on the basis of natural and man-made features which may limit or prohibit extractive development.

First, the physical context of the deposit is considered. Deposits with some physical constraint on ex-

tractive development, such as thick overburden or high water table, are less valuable resource areas because of the difficulties involved in resource recovery. Second, permanent man-made features, such as roads, railways, powerlines, and housing developments, which are built on a deposit, may prohibit its extraction. The constraining effect of legally required setbacks surrounding such features is included in the evaluation. A quantitative assessment of these constraints can be made by measurement of their areal extent directly from the topographic maps. The area rendered unavailable by these features is shown for each resource area in Table 3 (Column 3).

The assessment of sand and gravel deposits with respect to local land use and to private land ownership is an important component of the general evaluation process. These aspects of the evaluation process are not considered further in this report, but readers are encouraged to discuss them with personnel of the pertinent District Office of the Ontario Ministry of Natural Resources.

REGIONAL CONSIDERATIONS

In selecting sufficient areas for resource development, it is important to assess both the local and the regional resource base, and to forecast future production and demand patterns.

Some appreciation of future aggregate requirements in an area may be gained by assessing its present production levels and by forecasting future production trends. Such an approach is based on the assumptions that production levels in an area closely reflect the demand and that the present production "market share" of an area will remain roughly at the same level.

The aggregate resources in the region surrounding a municipality should be assessed in order to properly evaluate specific resource areas and to adopt optimum resource management plans. For example, a municipality that has large resources in comparison to its surrounding region constitutes a regionally significant resource area. Municipalites with high resources in proximity to large demand centres, such as metropolitan areas, are special cases.

Although an appreciation of the regional context is required to develop comprehensive resource management techniques, such detailed evaluation is beyond the scope of this report. The selection of resource areas made in this study is based primarily on geological data or on considerations outlined in preceding sections.

MAP 3: BEDROCK RESOURCES

Map 3 is an interpretative map derived from bedrock geology, drift thickness and bedrock topography maps, water well data from the Ontario Ministry of the Environment, oil and gas well data from the Petroleum Resources Section (Ontario Ministry of Natural Resources) and from geotechnical test hole data from various sources. Map 3 is based on concepts similar to those outlined for Maps 1 and 2, but displays both the inventory and evaluation on the one map.

The geological boundaries of the bedrock units are shown by a dashed line. Isolated outcrops are indicated by an "X". Three sets of contour lines delineate areas of less than 3 feet (1 m) of drift, areas of 3 to 25 feet (1 to 8 m) of drift, and areas of 25 to 50 feet (8 to 15 m) of drift. The extent of these areas of thin drift are shown by three shades of blue. The darkest shade indicates where bedrock outcrops or is within 3 feet (1 m) of the ground surface. These areas consitute potential resource areas because of their easy access. The medium shade indicates areas where drift cover is up to 25 feet (8 m) thick. Quarrying is possible in this depth of overburden and these zones also represent potential resource ares. The lightest shade indicates bedrock areas overlain by 25 to 50 feet (8 to 15 m) of overburden. These latter areas constitute resources which have extractive value only in specific circumstances. Outside of these delineated areas, the bedrock can be assumed to be covered by more than 50 feet (15 m) of overburden, a depth generally considered to be too great to allow economic extraction (unless part of the overburden is composed of economically attractive deposits).

Other inventory information presented on Map 3 is designed to give an indication of the present level of extractive activity in the report area. Those areas which are licenced for extraction under the Pits and Quarries Control Act are shown by a solid outline and identified by a number which refers to the quarry descriptions in Table 5. Each description notes the owner, location, licenced acreage and an estimate of face height. Unlicenced quarries (abandoned quarries or wayside quarries operating on demand under authority of a permit) are also identified and numbered on Map 3 and described in Table 5. One additional symbol appears on the map: an open dot indicates the location of a selected drill hole which penetrates bedrock. The overburden thickness is shown in feet beside the open dot.

SELECTION CRITERIA

Criteria equivalent to those used for sand and gravel deposits are used to select bedrock areas most favourable for extractive development.

The evaluation of bedrock resources is made primarily on the basis of performance and suitability data established by laboratory testing at the Ontario Ministry of Transportation and Communications. The main characteristics and uses of the bedrock units found in southern Ontario are summarized in Appendix D.

Deposit "size" is related directly to the areal extent of thin drift cover overlying favourable bedrock formations. Since vertical and lateral variations in bedrock units are much more gradual than in sand and gravel deposits, the quality and quantity of the resource are usually consistent over large areas.

Quality of the aggregate derived from specific bedrock units is established by the performance standards previously mentioned. Location and setting criteria and regional considerations are identical to those for sand and gravel deposits.

SELECTED RESOURCE AREAS

Selection of Bedrock Resource Areas has been restricted to a single level of significance. Three factors support this approch. First, quality and quantity variations are gradual. Second, the areal extent of a given quarry operation is much smaller than that of a sand and gravel pit producing an equivalent tonnage of material, and third, since crushed bedrock has a higher unit value than sand and gravel, longer haul distances can be considered. These factors allow the identification of alternative sites having similar development potential. The Selected Areas, if present, are shown on Map 3 by a line pattern and the calculated available tonnages are given in Table 6.

Selected Bedrock Resource Areas shown on Map 3 are not permanent, single land use units which must be incorporated in an official planning document. They represent areas in which a major bedrock resource is known to exist. Such Resource Areas may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

Part III — Assessment of Aggregate Resources in Sydenham Township

LOCATION AND POPULATION

Sydenham Township occupies an area of 77 756 acres (31 468 ha) in the northern part of Grey County in southern Ontario. The township is shown on the Owen Sound (41 A/10) and Markdale (41 A/7) map sheets of the National Topographic System, at a scale of 1:50 000. The surrounding municipalities are the townships of St. Vincent, Holland, and Derby and the City of Owen Sound.

In 1972, the population of Sydenham Township was 2475 (Ontario Ministry of Treasury, Economics and Intergovernmental Affairs 1974). In 1982, the population of the township was virtually unchanged at 2493 (Ontario Ministry of Municipal Affairs and Housing 1983). Projection to the year 2001 indicates a slight increase in population growth for all townships in Grey County (Ontario Ministry of Treasury, Economics and Intergovernmental Affairs 1976).

The major industrial, trade and retail centre for Sydenham Township is the neighbouring City of Owen Sound. There are no major urban centres in the township itself, although there are a number of small unincorporated hamlets, such as Annan, Leith, Woodford, Rockford, and Bognor. The township is largely rural in character with steadily growing rural residential and recreational developments especially along the Georgian Bay shoreline. The slow but steady growth in recreational developments indicates a continuing need for road-building and construction aggregate.

Road access in the township is provided by both paved and gravel- surfaced municipal roads as well as by King's Highways 6-10 and 26. Freight service is provided by a line of the Canadian Pacific Railway via Owen Sound. Shipping facilities are available at the Owen Sound harbour.

PHYSIOGRAPHY AND SURFICIAL GEOLOGY

Approximately 23 000 years ago, during the Late Wisconsinan Substage of the Pleistocene Epoch (informally known as the "Great Ice Age"), lobes or submasses of the Laurentide continental ice sheet advanced out of the Great Lakes basins and joined together to cover southern Ontario. The lateral extent of the ice lobes and the positions of their margins underwent numerous fluctuations until approximately 10 000 years ago when the ice melted back and completely disappeared. The physiography and distribution of surficial materials in Sydenham Township, and specifically the sand and gravel deposits shown on Map 1 of this report, are the result of the activities of the Georgian Bay ice lobe during the Late Wisconsinan Substage.

The landscape and land use activities of Sydenham Township have been described in detail by Chapman and Putnam (1966). The reader is specifically referred to descriptions of the following physiographic regions: Niagara Escarpment (pp. 173-188); Cape Rich Steps (pp. 196- 197); Bruce Peninsula (pp. 267-270); and Bighead Valley (pp. 194- 196). Detailed geological mapping and study of the geological history of the area has been undertaken by the Ontario Geological Survey (Feenstra, in prep.)

A strong advance of the Georgian Bay ice lobe left a drumlinized till plain over much of the township. The orientation of the drumlins indicates that the ice advance was in a southwesterly direction over the Niagara Escarpment, with some deflection to the south in the Bighead Valley region. The drumlinized till plain topography is most pronounced in the southern portion of the township. Here, the thickness of the till cover generally decreases towards the edge of the Niagara Escarpment, where bedrock is exposed. The till and drumlins are made up of a gravelly, sandy to clayey silt material. This material has mostly been derived from the less competent bedrock strata of the area. The till is not acceptable for aggregate use because of its excessive silt and clay content.

As the ice melted back from the area, ice-contact stratified drift was deposited at scattered locations along the ice front. These deposits are found south of Highway 26 and they can be described as small, irregular, kame-like mounds of generally less than 20 feet (6 m) thickness containing gravelly sand with occasional dirty sections because of the presence of silt and clay. Although these deposits offer limited aggregate potential, small gravel pits have been opened in them in the past to provide low-specification aggregate for local use. Very small esker deposits of similar resource potential are also found in the same area.

As the ice front melted back, low lying areas were intermittently blocked by ice barriers which restricted the flow of glacial meltwaters away from the ice. This resulted in extensive ponding of the meltwaters against the receding ice sheet. Eventually this process gave rise to the formation of glacial Lake Algonquin approximately 10 500 years ago. Further retreat of the ice front and uplift of the land resulted in the flooding of the lake basins in the south, giving rise to glacial Lake Nipissing approximately 5000 years ago. Deposits containing sediments associated with the activities of the above two prominent glacial lakes are found mostly in the vicinity of the present-day Georgian Bay shoreline.

Lacustrine silt and clay were laid down in the areas of deeper and quieter water, and predominantly silty fine sand was deposited in the nearshore shallow water areas. Small lacustrine sand deposits are found between Owen Sound and Balaclava. However, the sand is usually too fine grained for use in most road-building and construction aggregate products. Beach, baymouth and nearshore ridges containing mostly low quality tabular gravel derived from local bedrock and glacial till are found along the ancestral lake shorelines in the Balaclava-Leith-Owen Sound area. The larger beach deposits have been included on Map 1. Those beach deposits, which are located at the 750- to 775-foot (229 to 236 m) above sea level (a.s.l.) elevation, were formed by glacial Lake Algonquin. The lower beach deposits at the 625- to 650-foot (190 to 198 m) contour were built by glacial Lake Nipissing. Deposits of gravel and sand below the 625-foot (190 m) elevation in the Poynter Bay to Johnson Harbour area are regarded as post Nipissing to modern-day beach deposits (Feenstra, in prep.). The gravel beach deposits of Algonquin and older Nip-

issing age bear some economic resource potential for low-grade aggregate products if proper processing is undertaken. Unfortunately, in this township, most of these deposits are nearly depleted or are not large enough to support a viable economic operation.

More recent alluvial sediments of silt, sand, clay and some fine gravel are present along the banks of the rivers and creeks of the township. In some poorly drained areas and depressions on the river and creek floodplains, swampy and marshy conditions have developed. The alluvial sediments are not considered acceptable for aggregate use.

EXTRACTIVE ACTIVITY

A total of eight sand and gravel pits were identified in Sydenham Township. Most of the pits were partially overgrown or inactive at the time of investigation. At present, two of the eight pits are licenced to operate under the Pits and Quarries Control Act. The combined area of the licenced properties is 36.1 acres (14.6 ha). Extractive activities have been concentrated in the larger glaciolacustrine beach deposits and in the ice-contact stratified drift deposits. Most pits have a "low to moderate" pit use rating according to criteria established by the Ontario Ministry of Transportation and Communications (M.T.C.) (Deike 1982). According to this rating system, these pits are capable of supplying Granular Base Course A, B and C, and pit-run aggregate.

Records of the total annual production from all licenced and wayside pits have been kept by the Owen Sound District Office of the Ontario Ministry of Natural Resources since designation of the township under the Act in 1972. The average annual production from licenced sources between 1978 and 1983 was approximately 194,129 tons (176 114 tonnes). Production of sand and gravel for the same period from wayside pits (for which permits rather than licences are required) has been variable because of the fluctuating frequency of road construction activities in the area, but the total average annual production from these pits in the township was 67,500 tons (61 200 tonnes).

SELECTED SAND AND GRAVEL RESOURCE AREAS

Map 1 indicates the deposits which contain granular material in Sydenham Township. The total extent of these deposits in the township is approximately 2950 acres (1190 ha), representing an original tonnage of 55 million tons (50 million tonnes). Much of these resources have limited value for reasons of deposit size, thickness and quality of the material. Consequently, only the most significant sources are suggested for possible resource protection.

Sydenham Township is deficient in sand and gravel deposits which meet the criteria defined in Part II for deposit selection at the primary level of significance. The major reasons for this are the very limited remaining resources and generally low quality of the sand and gravel in the deposits. Consequently, only sources of secondary significance appear on Map 2. They include lacustrine beach deposits near the Georgian Bay shoreline and ice-contact stratified drift deposits on the Niagara Escarpment. Other deposits, such as the lacustrine plain sand deposits, are even less important and are classed at the tertiary level of significance.

SAND AND GRAVEL RESOURCE AREAS OF SECONDARY SIGNIFICANCE

Ice-contact stratified drift deposits associated with the retreating Georgian Bay ice sheet were formed south of Bothwell Corners and west and south of Bognor. These ice-contact deposits are kame-like, hummocky features of generally small areal extent with average thicknesses ranging from 4 to 15 feet (1.2 to 5 m). Wayside pits have been opened in these deposits in the past and most of them are now nearly depleted. Field assessment of pit faces and road cuts in these deposits indicate that they contain medium to coarse sand with some angular to subrounded medium gravel and occasional cobbles. The deposits are often capped by a thin layer of calcareous till, which contributes to the development of cementation in the underlying sand and gravel as the carbonate is leached out of the till by percolating rain water. Other deleterious characteristics, such as the presence of soft shale fragments and inclusions of silt and clay layers typical of ice-contact material, were also noted.

Two samples collected from these ice-contact deposits indicate 20 to 40 percent gravel content, respectively, with an insufficient percentage of crushable gravel (Figure 2a). Petrographic analysis performed on the samples by M.T.C. yielded Petrographic Numbers in excess of 135 suggesting that lithologically the material is only acceptable for low-specification aggregate uses. Pit use data compiled from files at M.T.C. (Deike 1982) show that in the past the aggregate from these deposits has been accepted for the production of Granular Base Course A, B and C, 16 mm Type B aggregate, and pit-run gravel. Remaining reserves in the ice-contact deposits are very low because of extensive previous extraction.

Five lacustrine beach gravel deposits are also included at the secondary level of significance. These resource areas are scattered between Balaclava and Leith and are situated along the former shorelines of glacial Lakes Algonquin and Nipissing. These deposits include sequences of beach bars made up of open framework, tabular medium to coarse gravel. In some locations, where the gravel is finer, the matrix is generally silty and clayey fine to coarse sand often with a slight reddish tint reflecting the proximity of the red Queenston Formation shale bedrock.

There were two licenced pits (pit nos. 1 and 2) and three unlicenced pits (pit nos. 3, 4 and 5) documented in these deposits during field investigation. Pit faces in licenced pit no. 1 showed 20 to 25 feet (6 to 8 m) of fine to coarse sand and fine to medium gravel with frequent seams of silt and clay. The gravel particles were rounded to subrounded and were predominantly limestone and dolostone derived from the local bedrock. Some rounded Precambrian cobbles and boulders occurred occasionally. Similar but somewhat cleaner material was found in pit no. 5. Pit nos. 2, 3 and 4 are in deposits where tabular gravel is predominant. These deposits are generally shallower and have an average deposit thickness of approximately 8 feet (2 m).

Laboratory analysis performed by M.T.C. on samples collected from beach deposits indicate that gravel content is in excess of 50 percent (Figure 2a). Petrographic Numbers were 241 and 166 for samples taken from pit no. 1 and pit no. 5, respectively. Magnesium Sulphate Soundness Losses were high, 18 and 11 percent, respectively. These test results suggest that the beach sand and gravel is only acceptable for aggregate products which have to meet less stringent specifications. Granular Base Course B and C and select subgrade material are the most common products that have been produced from these deposits in the past. Remaining reserves in these resource areas are meagre and alternate aggregate sources will be required for the township to provide high quality sand and gravel in sufficient quantities for local use.

BEDROCK GEOLOGY

Sydenham Township is underlain by shales of the Upper Ordovician Georgian Bay and Queenston Formations as well as by strata of the Lower to Middle Silurian Manitoulin, Cabot Head, Fossil Hill, Amabel and Guelph Formations. The distribution and stratigraphic relationships of these formations are shown on Map 3 (after Feenstra, in prep.; Liberty and Bolton 1971). The bedrock surface can be described as a flat, dissected cuesta-form landscape and the formations have a gentle regional dip to the southwest. Glacial sediments which overlie the bedrock surface are generally less than 25 feet (8 m) thick with abundant bedrock outcrops on the Niagara Escarpment and north of it in the vicinity of the Georgian Bay shoreline. The southeast corner of the township forms an exception. Here, drift thickness is in excess of 50 feet (15 m). Water well data northeast and southwest of Bognor indicate more than 300 feet (91 m) of drift suggesting that the area may be a drift-filled re- entrant valley in the Niagara Escarpment. The Niagara Escarpment itself is a dominant geological and geomorphological bedrock feature in southern Ontario. In Sydenham Township, the brow of the escarpment attains heights of 400 to 450 feet (122 to 137 m) above the water level of Georgian Bay and forms the eastern wall of the large Owen Sound re-entrant valley. In this area, the escarpment consists of a prominent bluff of Amabel dolostone and a secondary flat bench of Manitoulin dolostone.

The Georgian Bay Formation is the oldest bedrock unit. It includes alternating grey carbonate beds and grey to bluish grey shale (Liberty and Bolton 1971). The formation is over 400 feet (122 m) thick and, notwithstanding minor lithologic variation, its chemical composition is fairly consistent throughout its occurrence (Vos 1975). Georgian Bay shale is a raw material used for brick manufacture by some brick plants in southern Ontario and has also been used for the production of expanded aggregate in the past. At Meaford, east of the township, the shale is used for the manufacture of drain tile. It burns to a salmon-red, dense, hard body of relatively low absorption (Guillet 1977). The Georgian Bay Formation outcrops in a small area along the Georgian Bay shoreline in the northern corner of the township. In view of limited available reserves in this township and adequate supplies at Meaford, it has not been selected for possible resource protection.

The Georgian Bay Formation is overlain by the Queenston Formation which underlies the Owen Sound and Bighead River re-entrant valleys and forms the base of the Niagara Escarpment. The formation consists predominantly of red shale with occasional beds of mottled green shale (Liberty and Bolton 1971). The thickness is variable, ranging from 200 to 300 feet (61 to 91 m) in the Owen Sound area. Outcrops and thinly drift covered areas of Queenston shale are numerous in the north part of the township.

Queenston shale is a resource of provincial significance for the production of structural clay products. Analytical data presented by Guillet (1977) for Queenston shale from the Owen Sound area and the Toronto-Hamilton area indicate, however, that the shale in the Owen Sound area may have less use potential because it tends to have a much higher lime content. Excessive lime content affects final product colour and may also cause cracking of the product during the cooling cycle after firing. Queenston shale samples taken from the Owen Sound area also failed to produce acceptable test results for expanded aggregate use (Wilson 1963). Although there is an intermittent history of small-scale brick and tile manufacture from Queenston shale in the Owen Sound area (Guillet 1967), the Queenston shale has not been selected for possible resource protection because of the quality limitations discussed above.

The Queenston Formation is overlain by grey and bluish grey, thin- to medium-bedded, fine-grained dolomitic limestone of the Manitoulin Formation. Argillaceous partings which weather into thin irregular beds, white weathering chert in thin nodular layers or in nodules, and traces of pyrite are often common in this rock formation. Goudge (1938) reported that in several now-abandoned quarries in the neighbouring City of Owen Sound the cherty Manitoulin Formation was extracted for use as crushed stone, rubble and foundation stone.

In Sydenham Township the Manitoulin Formation forms a thinly drift covered flat bench paralleling the north-facing side of the escarpment. Outcrops are common but the formation is best exposed at roadcuts in the escarpment. A sample of Manitoulin bedrock collected from a roadcut face at Lot 25, Concession 3 has been analyzed by M.T.C. Petrographic analysis of the sample showed that the quality of this dolomitic limestone is not sufficiently high to make it suitable for use as Hot-Laid No. 4 stone or any higher specification aggregate product. Another exposure sampled in Sarawak Township showed similar results (B.H. Feenstra, Mineral Resources Geologist, Southwestern Region, Ontario Ministry of Natural Resources, London, personal communication, 1984). Because of the availability of a better quality bedrock resource in the Amabel Formation, the Manitoulin Formation has not been selected for possible resource protection.

The calcareous shale of the Cabot Head Formation overlies the Manitoulin Formation and forms much of the lower face of the Niagara Escarpment (Liberty and Bolton 1971). The shale is too soft for use as load-bearing aggregate. This formation has been mapped together with the Manitoulin Formation on Map 3 because of its limited lateral extent.

The Fossil Hill Formation can be observed overlying shale of the Cabot Head Formation along the face of the Niagara Escarpment. The Fossil Hill Formation is described as a grey weathering, brown, irregularly thin bedded, fossiliferous, often cherty dolostone. The contact between this formation and the overlying Amabel Formation is exposed in the township along Highway 26 at the Woodford roadcut (Telford and Narain 1980). Since exposures of the Fossil Hill dolostone are very limited along the face of the escarpment, the formation has been grouped together with the overlying Amabel Formation on Map 3.

The erosion-resistant dolostone of the Amabel Formation forms the cap rock of the Niagara Escarpment and underlies approximately one third of the township south and west of the edge of the escarpment. The formation in this area largely consists of light buff to blue, finely crystalline dolostone although minor amounts of porous medium- to coarse-grained dolostone and patches of dark brown, bituminous dolostone may also occur (Bolton 1957; Liberty and Bolton 1971). The Amabel Formation is suitable for use in crushed stone, concrete aggregate, building stone and as raw material for lime manufacture. The Amabel is considered an aggregate source of provincial significance because of its generally high quality. Those areas of the Amabel Formation that are overlain by less than 25 feet (8 m) of drift in Sydenham Township have been selected for possible resource protection.

The Amabel Formation often contains an abundance of reefs which are commonly 50 to 60 feet (15 to 18 m) in height and a few hundred feet in diameter (Hewitt 1960). Reef rock from the Amabel Formation is highly porous (and therefore absorptive), softer and less durable than the surrounding rock, and may contain clay pockets and iron staining, particularly near the surface (Hewitt 1960). For these reasons the quality of the reefal rock may be impaired for use as aggregate. However, the inter-reef rock deposited between the reefs is of high quality and is well suited for extraction and use. Extractive operations are, therefore, better located in the inter- reef areas.

The Guelph Formation is the youngest bedrock unit and underlies a small area in the southwest corner of the township. The formation is a buff and brown, fine- to medium-grained dolostone and both reefal and inter-reefal varieties occur (Liberty and Bolton 1971). The massive, porous, softer, coarser-grained reefal strata are not as well suited for aggregate use as the evenly-bedded, inter-reefal dolostone. The Guelph Formation is also a valuable raw material for a range of metallurgical products because of the usually high chemical purity. It is quarried for the production of dolomitic lime near Guelph and Hamilton. The Guelph Formation has not been selected for possible resource protection because very large resources of more durable Amabel dolostone are available in the township and local markets for metallurgical products are lacking in the area.

SELECTED BEDROCK RESOURCE AREAS 1a TO 1f AND 2a TO 2g

Selected Bedrock Resource Areas 1a to 1f and 2a to 2g consist of all those areas where the Amabel Formation is overlain by less than 25 feet (8 m) of glacial sediments. The northern and southern limits of these areas are defined by the brow of the Niagara Escarpment, which trends northeast-southwest across the central part of the township. Most of the resource areas are very thinly drift covered, except for the area southwest of Hoath Head, where the bedrock is masked by a drumlinized till plain.

At the turn of the century, several quarries had been opened in Amabel dolostone along the Niagara Escarpment in the Owen Sound area (Goudge 1938). Later, all these quarries were abandoned. More recently, a crushed stone quarry (quarry no. Q1) was developed by E.C. King Contracting Limited in Selected Resource Area 1a southeast of Bothwell Corners. The quarry face exposes 30 to 40 feet (9 to 12 m) of grey and buff, mottled, medium- to fine-crystalline, moderately porous, medium- to thick-bedded, occasionally fossiliferous and vuggy dolostone. Products available from this quarry include a variety of fine and coarse crushed aggregate as well as general oversize rock products. Test data obtained from M.T.C. for samples taken from this quarry show that the material is satisfactory for most high- specification uses, although absorption test results for some of the samples exceed the allowable limits (Deike 1982).

The Amabel dolostone is usually of high quality, however, porous reefal structures and chert, where encountered, may restrict some high-specification uses of the aggregate. For these reasons, the quality of the bedrock should be investigated at specific sites proposed for possible future quarry development before extraction begins. A significant thickness of Amabel dolostone may be suitable for quarrying as exposures of up to 40 feet (12 m) high can be observed along the brow of the escarpment and the formation's thickness increases in an apparent southwesterly direction away from the escarpment (Vos 1969).

The Selected Bedrock Resource Areas have a combined area of 24,400 acres (9900 ha), of which 21,500 acres (8700 ha) are presently available for extraction. Assuming an average workable thickness of 60 feet (18 m), available bedrock resources are estimated to be approximately 4650 million tons (4200 million tonnes). Considerable portions of the selected resource areas near Woodford and Bothwell Corners lie within policy areas of the Niagara Escarpment Commission and may be unavailable for future extractive development. There exist, however, alternate locations within the selected resource areas for possible future quarry developments should local markets so demand. The resource areas are readily accessible by Highways 6-10 and 26, numerous paved county and township roads and a Canadian Pacific rail line which runs parallel with the township's western boundary.

SUMMARY

The sand and gravel deposits of Sydenham Township are the product of glacial processes which took place during the Late Wisconsinan Substage of the Pleistocene Epoch. The deposits have been mapped as shallow accumulations of ice-contact stratified drift and lacustrine plain and beach deposits. These deposits offer marginal remaining reserves of aggregate which is best suited for low-specification uses. Because of the general lack of high quality surficial aggregate deposits in the township, only selected resource areas of secondary significance have been outlined. Care should be taken to ensure the continued availability of as much of these resource areas as possible. The remaining possible resources of sand and gravel will be insufficient for local needs in the future and will require augmentation from other sources.

The township is underlain by Upper Ordovician to Middle Silurian age shales and dolostones. The Niagara Escarpment is the most prominent bedrock feature and traverses the township in a northeast-southwesterly direction. The Amabel Formation, which is the cap rock of the escarpment, is considered the most acceptable for extractive development. The generally high quality Amabel dolostone can be used for the production of a wide range of industrial mineral products. Several large areas (Resource Areas 1a to 1f and 2a to 2g) of thinly drift covered Amabel dolostone have been selected for possible resource protection. The availability of some of the bedrock resources may be restricted because they fall within the policy areas of the Niagara Escarpment Commission.

Enquiries regarding the Aggregate Resources Inventory of Sydenham Township should be directed to the Ontario Ministry of Natural Resources either at the Owen Sound District Office, 611 - 9th Avenue East, Owen Sound, Ontario, N4K 3E4 (Tel. (519) 376-3860) or at the Southwestern Region Geological Office, 458 Central Avenue, London, Ontario, N6B 2E5 (Tel. (519) 433-8431).

TABLE 1. TOTAL SAND AND GRAVEL RESOURCES, SYDENHAM TOWNSHIP*.

1 Class No.	2 Deposit Type (see Appendix C)	3 Areal Extent Acres (Hectares)	4 Original Tonnage Millions of Tons (Tonnes)
1	S-IC	92 (37)	5 (4)
	G-LB	44 (18)	2 (2)
2	S-IC	171 (69)	6 (5)
	S-LP	135 (55)	5 (4)
	G-LB	60 (24)	2 (2)
3	S-IC	295 (119)	6 (5)
	S-LP	183 (74)	4 (4)
	S-OW	60 (24)	1 (1)
	S-WD-LB	175 (71)	4 (4)
	G-LB	330 (134)	7 (6)
4	S-E	112 (45)	1 (1)
	S-IC	40 (16)	<1 (<1)
	G-LB	1020 (413)	10 (9)
	S-LP	247 (100)	2 (1)
		2950 (1190)	55 (50)

N.B. Minor variations in all tables are caused by rounding of data.

TABLE 2. SAND AND GRAVEL PITS, SYDENHAM TOWNSHIP.

1 No.	2 MTC No.	3 Owner/ Operator	4 Lot	5 Con.	6 Licenced Areas Acres (Hectares)	7 Face Height Feet Metres	8 % Gravel
LICENCED PITS							
1	O6-42	Mr. James McArthur	21	B	18.3 (7.4)	20-25 (6-8)	30-60
2	-	Mr. Keith Burnstead	21	C	17.8 (7.2)	8-10 (2-3)	50-60 (nearly depleted)
					36.1 (14.6)		
UNLICENCED PITS*							
3	-	Johnson	9	C		4-6 (1.2-2)	60-80 (partially overgrown)
4	-	Unknown	24	B		8-12 (2-4)	30-60 (overgrown)
5	O6-20 O6-43	Day & Wale	Pt.30, 31	A		15-20 (5-6)	60-70 (partially overgrown)
6	O6-1 O6-31	Kinch & More	15	10		10 (3)	10 (depleted)
7	O6-5	McArthur	7	5		25-30 (8-9)	30-50 (nearly depleted)
8	-	Unknown	3	5		25-30 (8-9)	20-60 (variable, partially overgrown)

N.B. Minor variations in all tables are caused by rounding of data.

*Abandoned pits or wayside pits operating on demand under authority of a permit.

TABLE 3. SELECTED SAND AND GRAVEL RESOURCE AREAS, SYDENHAM TOWNSHIP.

1 **Deposit No.**	2 **Unlicenced Area** Acres (Hectares)	3 **Cultural Setbacks** Acres (Hectares)	4 **Extracted Area** Acres (Hectares)	5 **Available Area** Acres (Hectares)	6 **Estimated Deposit Thickness** Feet (Metres)	7 **Available Aggregate** Millions of Tons (Tonnes)
			-NONE-			

N.B. Minor variations in all tables are caused by rounding of data.

TABLE 4. TOTAL IDENTIFIED BEDROCK RESOURCES, SYDENHAM TOWNSHIP

1 DRIFT THICKNESS Feet (Metres)	2 FORMATION	3 ESTIMATED DEPOSIT THICKNESS Feet (Metres)	4 AREAL EXTENT Acres (Hectares)	5 ORIGINAL TONNAGE Millions of Tons (Tonnes)
3-25	Guelph	60	600	130
(1-8)		(18)	(243)	(118)
25-50	Guelph	60	770	166
(8-15)		(18)	(310)	(151)
			1370	295
			(550)	(270)
0-3	Amabel &	60	17,000	3650
(0-1)	Fossil Hill	(18)	(6900)	(3300)
3-25	Amabel &	60	7600	1640
(1-8)	Fossil Hill	(18)	(3100)	(1490)
25-50	Amabel &	60	2000	430
(8-15)	Fossil Hill	(18)	(810)	(390)
			26,500	5700
			(10 700)	(5200)
0-3	Cabot Head &	60	3250	620
(0-1)	Manitoulin	(18)	(1320)	(560)
3-25	Cabot Head &	60	5100	980
(1-8)	Manitoulin	(18)	(2060)	(890)
25-50	Cabot Head &	60	7800	1680
(8-15)	Manitoulin	(18)	(3150)	(1520)
			16,200	3300
			(6600)	(3000)
0-3	Queenston	60	12,600	2400
(0-1)		(18)	(5100)	(2180)
3-25	Queenston	60	3200	610
(1-8)		(18)	(1300)	(550)
25-50	Queenston	60	181	36
(8-15)		(18)	(73)	(33)
			16,000	3050
			(6500)	(2750)
0-3	Georgian Bay	60	1580	315
(0-1)		(18)	(640)	(285)
3-25	Georgian Bay	60	320	63
(1-8)		(18)	(130)	(57)
			1900	380
			(770)	(345)
			62,000	12,700
			(25 000)	(11 500)

N.B. Minor variations in all tables are caused by rounding of data.

TABLE 5. QUARRIES, SYDENHAM TOWNSHIP.

1 NO.	2 MTC NO.	3 OWNER/ OPERATOR	4 LOT	5 CON.	6 LICENCED AREA Acres (Hectares)	7 FACE HEIGHT Feet (Metres)
LICENCED QUARRY						
1	O6-54	E.C. King Contracting Limited	24 Pt.23 &25 Pt.21	SCR 2SCR 1SCR	249.5 (101.0)	30-40 (9-12)

N.B. Minor variations in all tables are caused by rounding of data.

TABLE 6. SELECTED BEDROCK RESOURCE AREAS, SYDENHAM TOWNSHIP.

1 DEPOSIT NO.	2 DEPTH OF OVERBURDEN Feet (Metres)	3 UNLICENCED AREA Acres (Hectares)	4 CULTURAL SETBACKS Acres (Hectares)	5 EXTRACTED AREA Acres (Hectares)	6 AVAILABLE AREA Acres (Hectares)	7 ESTIMATED WORKABLE THICKNESS Feet (Metres)	8 AVAILABLE RESOURCES Millions of Tons (Tonnes)
1a	0-3	14,400	1100	0	13,300	60	2850
	(0-1)	(5800)	(445)	(0)	(5400)	(18)	(2600)
1b	0-3	2200	600	0	1600	60	345
	(0-1)	(890)	(245)	(0)	(650)	(18)	(315)
1c	0-3	50	20	0	30	60	6
	(0-1)	(20)	(8)	(0)	(12)	(18)	(5)
1d	0-3	25	10	0	15	60	3
	(0-1)	(10)	(4)	(0)	(6)	(18)	(3)
1e	0-3	40	5	0	35	60	8
	(0-1)	(16)	(2)	(0)	(14)	(18)	(7)
1f	0-3	105	20	0	85	60	18
	(0-1)	(42)	(8)	(0)	(34)	(18)	(16)
		16,800	1760	0	15,100		3250
		(6800)	(710)	(0)	(6100)		(2950)
2a	3-25	7000	1000	0	6000	60	1300
	(1-8)	(2850)	(405)	(0)	(2430)	(18)	(1180)
2b	3-25	110	60	0	50	60	11
	(1-8)	(44)	(24)	(0)	(20)	(18)	(10)
2c	3-25	75	40	0	35	60	8
	(1-8)	(30)	(16)	(0)	(14)	(18)	(7)
2d	3-25	95	20	0	75	60	16
	(1-8)	(38)	(8)	(0)	(30)	(18)	(14)
2e	3-25	220	20	0	200	60	43
	(1-8)	(89)	(8)	(0)	(81)	(18)	(39)
2f	3-25	35	20	0	15	60	3
	(1-8)	(14)	(8)	(0)	(6)	(18)	(3)
2g	3-25	40	5	0	35	60	8
	(1-8)	(16)	(2)	(0)	(14)	(18)	(7)
		7600	1160	0	6400		1390
		(3100)	(470)	(0)	(2600)		(1260)
		24,400	2900	0	21,500		4650
		(9900)	(1170)	(0)	(8700)		(4200)

N.B. Minor variations in all tables are caused by rounding of data.

TABLE 7. SUMMARY OF TEST HOLE DATA, SYDENHAM TOWNSHIP.

-NONE-

N.B. Minor variations in all tables are caused by rounding of data.

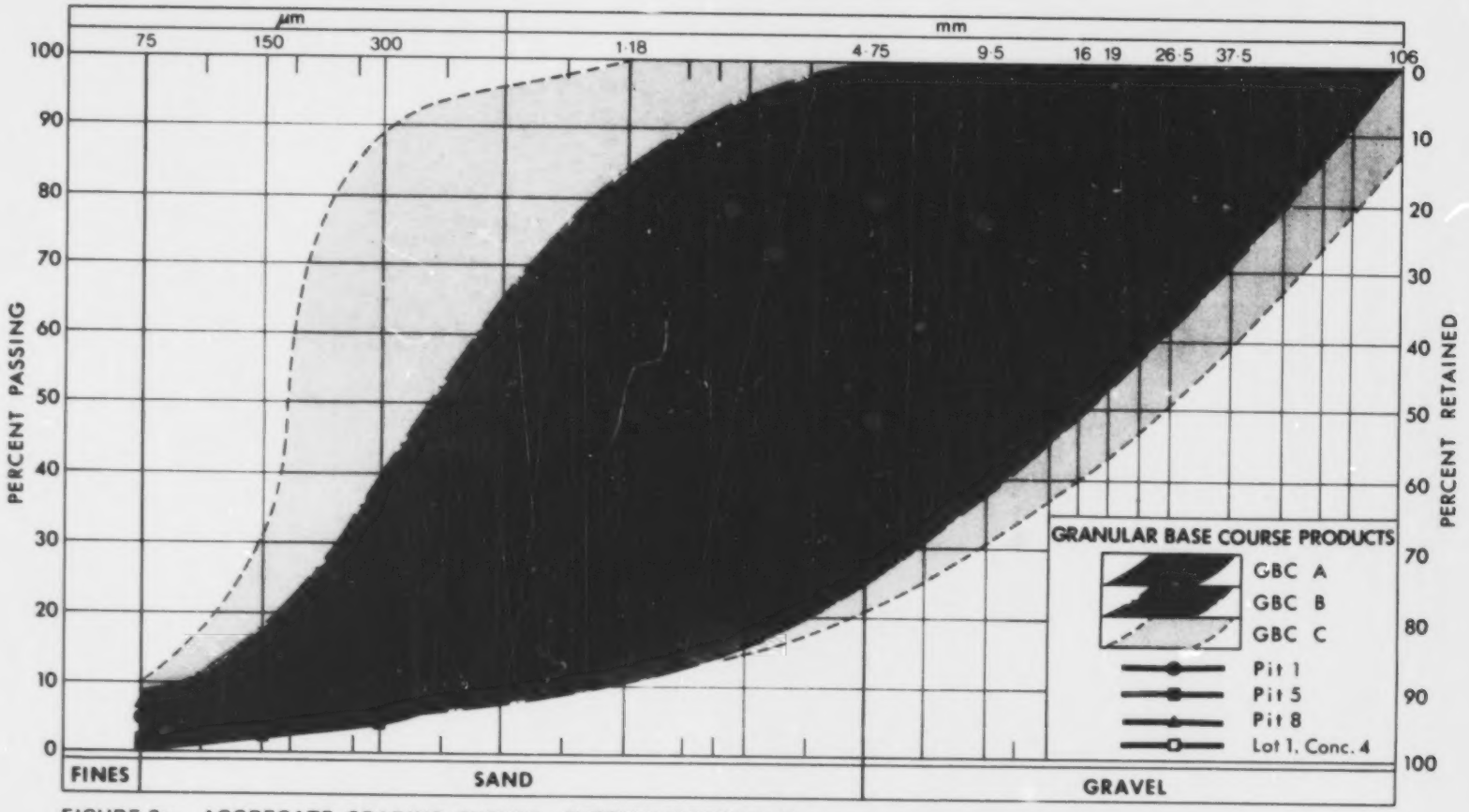


FIGURE 2a: AGGREGATE GRADING CURVES, SYDENHAM TOWNSHIP;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

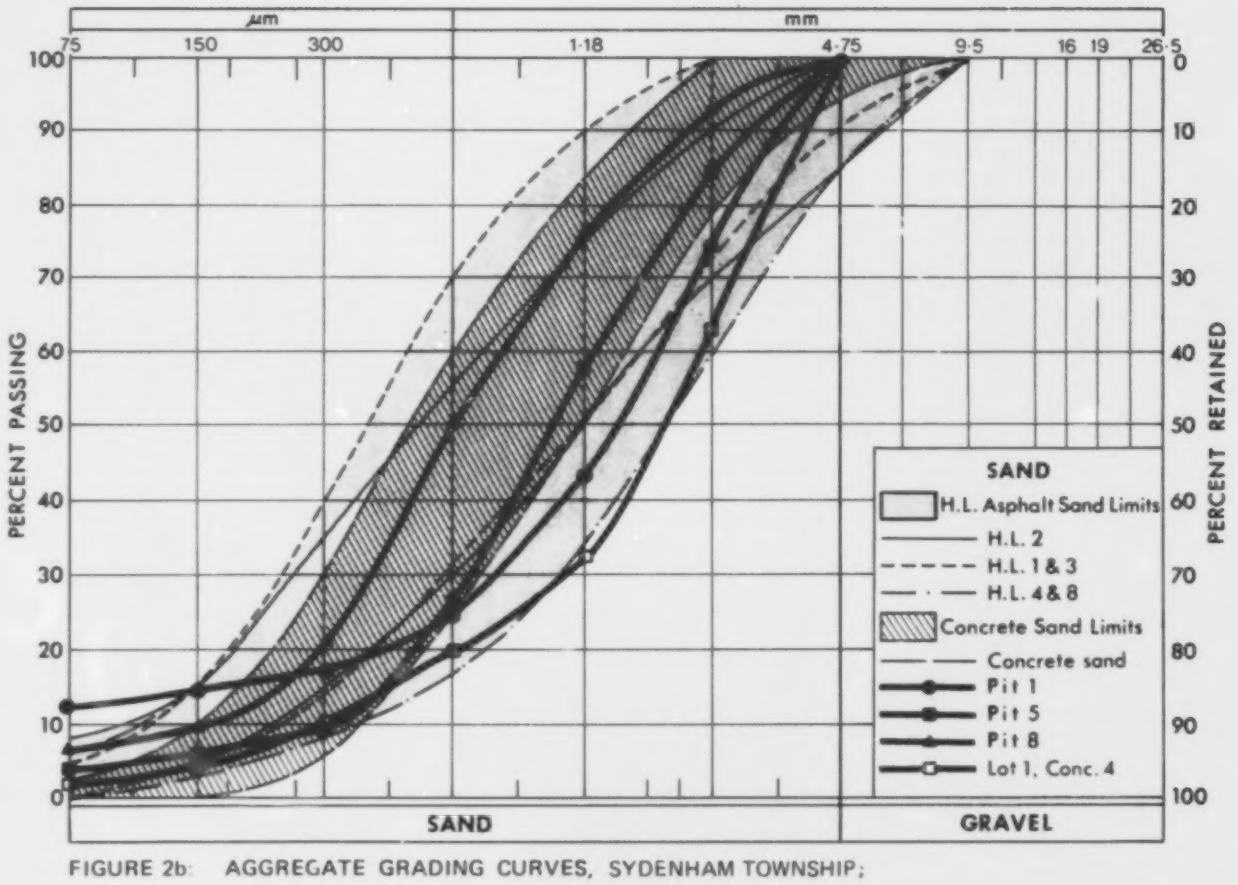


FIGURE 2b: AGGREGATE GRADING CURVES, SYDENHAM TOWNSHIP;

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

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Appendix B — Glossary

Abrasion resistance: Tests such as the Los Angeles abrasion test are used to measure the ability of aggregate to resist crushing and pulverizing under conditions similar to those encountered in processing and use. Measuring resistance is an important component in the evaluation of the quality and prospective uses of aggregate. Hard, durable material is preferred for road building.

Absorption capacity: Related to the porosity of the rock types of which an aggregate is composed. Porous rocks are subject to disintegration when absorbed liquids freeze and thaw, thus decreasing the strength of the aggregate.

Aggregate: Any hard, inert, construction material (sand, gravel, shells, slag, crushed stone or other mineral material) used for mixing in various-sized fragments with a cement or bituminous material to form concrete, mortar, etc., or used alone for road building or other construction. Synonyms include mineral aggregate and granular material.

Alkali-aggregate reaction: A chemical reaction between the alkalis of portland cement and certain minerals found in rocks used for aggregate. Alkali-aggregate reactions are undesirable because they can cause expansion and cracking of concrete. Although perfectly suitable for building stone and asphalt applications, alkali-reactive aggregates should be avoided for structural concrete uses.

Blending: Required in cases of extreme coarseness, fineness, or other irregularities in the gradation of unprocessed aggregate. Blending is done with approved sand-sized aggregate in order to satisfy the gradation requirements of the material.

Cambrian: The first period of the Palezoic Era, thought to have covered the time between 570 and 500 million years ago. The Cambrian precedes the Ordovician Period.

Clast: An individual constituent, grain or fragment of a sediment or rock, produced by the mechanical weathering of larger rock mass. Synonyms include particle and fragment.

Crushable aggregate: Unprocessed gravel containing a minimum of 35 percent coarse aggregate larger than the No. 4 sieve (4.75 mm) as well as a minimum of 20 percent greater than the 26.5 mm sieve.

Deleterious lithology: A general term used to designate those rock types which are chemically or physically unsuited for use as construction or road-building aggregates. Such lithologies as chert, shale, siltstone and sandstone may deteriorate rapidly when exposed to traffic and other environmental conditions.

Devonian: A period of the Paleozoic Era thought to have covered the span of time between 395 and 345 million years ago, following the Silurian Period. Rocks formed in the Devonian Period are among the youngest found in Ontario.

Dolostone: A carbonate sedimentary rock consisting chiefly of the mineral dolomite and containing relatively little calcite (dolostone is also known as dolomite).

Drift: A general term for all unconsolidated rock debris transported from one place and deposited in another, distinguished from underlying bedrock. In North America, glacial activity has been the dominant mode of transport and deposition of drift. Synonyms include overburden and surficial deposit.

Drumlin: A low, smoothly rounded, elongated hill, mound, or ridge composed of glacial materials. These landforms were formed beneath an advancing ice sheet, and were shaped by its flow.

Eolian: Pertaining to the wind, especially with respect to landforms whose constituents were transported and deposited by wind activity. Sand dunes are an example of an eolian landform.

Fines: A general term used to describe the size fraction of an aggregate which passes (is finer than) the No. 200 mesh screen (0.075 mm). Also described informally as "dirt", these particles are in the silt and clay size range.

Glacial lobe: A tongue-like projection from the margin of the main mass of an ice cap or ice sheet. During the Pleistocene Epoch several lobes of the Laurentide continental ice sheet occupied the Great Lakes basins. These lobes advanced then melted back numerous times during the Pleistocene, producing the complex arrangement of glacial material and landforms found in southern Ontario.

Gradation: The proportion of material of each particle size, or the frequency distribution of the various sizes which constitute a sediment. The strength, durability, permeability and stability of an aggregate depend to a great extent on its gradation. The size limits for different particles are as follows:

Boulder	more than 200 mm
Cobbles	75-200 mm
Coarse Gravel	26.5-75 mm
Fine Gravel	4.75-26.5 mm
Coarse Sand	2-4.75 mm
Medium Sand	0.425-2 mm
Fine Sand	0.075-0.425 mm
Silt, Clay	less than 0.075 mm

Granular base course: Components of the pavement structure of a road, which are placed on the subgrade and are designed to provide strength, stability and drainage, as well as support for surfacing materials. Several types have been defined: Granular Base Course A consists of crushed and processed aggregate and has relatively stringent quality standards in comparison to Granular Base Course B and C which are usually pit-run or other unprocessed aggregate.

Hot-laid (or asphaltic) aggregate: Bituminous, cemented aggregates used in the construction of pavements either as surface or bearing course (H.L. 1, 3 and 4), or as binder course (H.L. 2 and 8) used to bind the surface course to the underlying granular base course.

Lithology: The description of rocks on the basis of such characteristics as color, structure, mineralogic composition and grain size. Generally, the description of the physical character of a rock.

Magnesium sulphate soundness test: This test is designed to simulate the action of freezing and thawing on aggregates. Those aggregates which are susceptible will usually break down and give high losses in this test.

Meltwater channel: A drainage way, often terraced, produced by water flowing away from a melting glacier margin.

Ordovician: an early period of the Paleozoic Era thought to have covered the span of time between 500 and 435 million years ago.

Paleozoic Era: One of the major divisions of the geologic time scale thought to have covered the time between 570 and 230 million years ago, the Paleozoic Era (or Ancient Life Era) is subdivided into six geologic periods, of which only four (Cambrian, Ordovician, Silurian and Devonian) can be recognized in southern Ontario.

Petrographic examination: An aggregate quality test based on known field performance of various rock types. The test result is a Petrographic Number (P.N.). The higher the P.N. the lower the quality of the aggregate.

Pleistocene: An epoch of the recent geological past including the time from approximately 2 million years ago to 7000 years ago. Much of the Pleistocene was characterized by extensive glacial activity and is popularly referred to as the "Great Ice Age".

Possible resource: Reserve estimates based largely on broad knowledge of the geological character of the deposit and for which there are few, if any, samples or measurements. The estimates are based on assumed continuity or repetition for which there are reasonable geological indications.

Shale: A fine-grained, sedimentary rock formed by the consolidation of clay, silt or mud and characterized by well developed bedding planes, along which the rock breaks readily into thin layers. The term shale is also commonly used for fissile claystone, siltstone and mudstone.

Silurian: An early period of the Palezoic Era thought to have covered the time between 435 and 395 million years ago. The Silurian follows the Ordovician Period and precedes the Devonian Period.

Soundness: The ability of the components of an aggregate to withstand the effects of various weathering processes and agents. Unsound lithologies are subject to disintegration caused by the expansion of absorbed solutions. This may seriously impair the performance of road-building and construction aggregates.

Till: Unsorted and unstratified rock debris, deposited directly by glaciers, and ranging in size from clay to large boulders.

Wisconsinan: Pertaining to the last glacial period of the Pleistocene Epoch in North America. The Wisconsinan began approximately 100 000 years ago and ended approximately 7000 years ago. The glacial deposits and landforms of southern Ontario are predominantly the result of glacial activity during the Wisconsinan Stage.

Appendix C — Geology of Sand and Gravel Deposits

The type, distribution, and extent of sand and gravel deposits in southern Ontario are the result of extensive glacial and glacially influenced activity in Wisconsinan time during the Pleistocene Epoch, approximately 100 000 to 7000 years ago. The deposit types reflect the different depositional environments that existed during the melting and retreat of the continental ice masses, and can readily be differentiated on the basis of their morphology, structure, and texture. The deposit types are described below.

GLACIOFLUVIAL DEPOSITS

These deposits can be divided into two broad categories: those that were formed in contact with (or in close proximity to) glacial ice, and those that were deposited by meltwaters carrying materials beyond the ice margin.

Ice-Contact Terraces (ICT): These are glaciofluvial features deposited between the glacial margin and a confining topographic high, such as the side of a valley. The structure of the deposits may be similar to that of outwash deposits, but in most cases the sorting and grading of the material is more variable and the bedding is discontinuous because of extensive slumping. The probability of locating large amounts of crushable aggregate is moderate, and extraction may be expensive because of the variability of the deposits both in terms of quality and grain size distribution.

Kames (K): Kames are defined as mounds of poorly sorted sand and gravel deposited by meltwater in depressions or fissures on the ice surface or at its margin. During glacial retreat, the melting of supporting ice causes collapse of the deposits, producing internal structures characterized by bedding discontinuities. The deposits consist mainly of irregularly bedded and crossbedded, poorly sorted sand and gravel. The present forms of the deposits include single mounds, linear ridges (crevasse fillings) or complex groups of landforms. The latter are occasionally described as "undifferentiated ice-contact stratified drift" (IC) when detailed subsurface information is unavailable. Since kames commonly contain large amounts of fine-grained material and are characterized by considerable variability, there is generally a low to moderate probability of discovering large amounts of good quality, crushable aggregate. Extractive problems encountered in these deposits are mainly the excessive variability of the aggregate and the rare presence of excess fines (silt- and clay-sized particles).

Eskers (E): Eskers are narrow, sinuous ridges of sand and gravel deposited by meltwaters flowing in tunnels within or at the base of glaciers, or in channels on the ice surface. Eskers vary greatly in size. Many, though not all eskers consist of a central core of poorly sorted and stratified gravel characterized by a wide range in grain size. The core material is often draped on its flanks by better sorted and stratified gravel characterized by a wide range in grain size. The core material is often draped on its flanks by better sorted and stratified sand and gravel. The deposits have a high probability of containing a large proportion of crushable aggregate, and since they are generally built above the surrounding ground surface, are convenient extraction sites. For these reasons esker deposits have been traditional aggregate sources throughout Ontario, and are significant components of the total resources of many areas.

Some planning constraints and opportunities are inherent in the nature of the deposits. Because of their linear nature, the deposits commonly extend across several property boundaries leading to unorganized extractive development at numerous small pits. On the other hand, because of their form, eskers can be easily and inexpensively extracted and are amenable to rehabilitation and sequential land use.

Undifferentiated Ice-Contact Stratified Drift (IC): This designation may include deposits from several ice-contact, depositional environments which usually form extensive, complex landforms. It is not feasible to identify individual areas of coarse-grained material within such deposits because of their lack of continuity and grain size variability. They are given a qualitative rating based on existing pit and other subsurface data.

Outwash (OW): Outwash deposits consist of sand and gravel laid down by meltwaters beyond the margin of the ice lobes. The deposits occur as sheets or as terraced valley fills (valley trains) and may be very large in extent and thickness. Well developed outwash deposits have good horizontal bedding and are uniform in grain size distribution. Outwash deposited near the glacier's margin is much more variable in texture and structure. The probability of locating useful crushable aggregates in outwash deposits is moderate to high depending on how much information on size, distribution and thickness is available.

Alluvium (AL): Alluvium is a general term for clay, silt, sand, gravel, or similar unconsolidated material deposited during postglacial time by a stream as sorted or semi-sorted sediment, on its bed or on its floodplain. The probability of locating large amounts of crushable aggregate in alluvial deposits is low, and they have generally low value because of the presence of excess silt- and clay-sized material. There are few large postglacial alluvium deposits in Ontario.

GLACIOLACUSTRINE DEPOSITS

Glaciolacustrine Beach Deposits (LB): These are relatively narrow, linear features formed by wave action at the shores of glacial lakes that existed at various times during the deglaciation of southern Ontario. Well developed lacustrine beaches are usually less than 20 feet (6 m) thick. The aggregate is well sorted and stratified and sand-sized material commonly predominates. The composition and size distribution of the deposit depends on the nature of the source material. The probability of obtaining crushable aggregate is high when the material is developed from coarse-grained materials such as a stony till, and low when developed from fine-grained materials. Beaches are relatively narrow, linear deposits, so that extractive operations are often numerous and extensive.

Glaciolacustrine Deltas (LD): These features were formed where streams or rivers of glacial meltwater flowed into lakes and deposited their suspended sediment. In southern Ontario such deposits tend to consist mainly of sand and abundant silt. However, in near- ice and ice-contact positions, coarse material may be present. Although deltaic deposits may be large, the probability of obtaining coarse material is generally low.

Glaciolacustrine Plains (LP): The nearly level surface marking the floor of an extinct glacial lake. The sediments which form the plain are predominantly fine to medium sand, silt, and clay, and were deposited in relatively deep water. Lacustrine deposits are generally of low value as aggregate sources because of their fine grain size and lack of crushable material. In some aggregate-poor areas, lacustrine deposits may constitute valuable sources of fill and some granular base course aggregate.

GLACIAL DEPOSITS

End Moraines (EM): These are belts of glacial drift deposited at, and parallel to, glacier margins. End moraines commonly consist of ice-contact stratified drift and in such instances are usually called kame moraines. Kame moraines commonly result from deposition between two glacial lobes (interlobate moraines). The probability of locating aggregates within such features is moderate to low. Exploration and development costs are high. Moraines may be very large and contain vast aggregate resources, but the location of the best areas within the moraine is usually poorly defined.

EOLIAN DEPOSITS

Windblown Deposits (WD): Windblown deposits are those formed by the transport and deposition of sand by winds. The form of the deposits ranges from extensive, thin layers to well developed linear and crescentic ridges known as dunes. Most windblown deposits in southern Ontario are derived from, and deposited on, pre-existing lacustrine sand plain deposits. Windblown sediments almost always consists of fine to coarse sand and are usually well sorted. The probability of locating crushable aggregate in windblown deposits is very low.

Appendix D — Geology of Bedrock Deposits

BEDROCK SUITABLE FOR CRUSHED STONE PRODUCTS

Bass Islands Formation (Upper Silurian)

(Includes the Bertie Formation of the Niagara Peninsula) Composition: Medium- to massive-bedded, aphanitic, brown dolostone with shaly partings. Thickness: 35 to 60 feet (11 to 18 m) near Hagersville. Uses: Quarried for crushed stone on the Niagara Peninsula at Fort Erie, Cayuga, Hagersville, and Dunnville. Los Angeles Abrasion Test: 17-35% loss; Absorption: 1.4%. Shaly parts are unsuitable for aggregate because of high soundness losses.

Bobcaygeon Formation (Middle Ordovician)

Composition: Compact, homogeneous, medium- to thin-bedded, fine- grained limestone with some argillaceous and shaly partings. Thickness: The lower unit is 40 to 72 feet (12 to 22 m) thick in the east and the remainder of the formation is 40 feet (12 m). Uses: Quarried at Kirkfield and Marysville for crushed stone. The Bobcaygeon Formation has consistently acceptable quality for granular base course materials and concrete.

Bois Blanc Formation (Lower-Middle Devonian)

Composition: Brownish grey, medium-crystalline, medium- to thin- bedded, cherty limestone, commonly fossiliferous. Limestone may be silty or sandy in places. Thickness: 9 to 200 feet (3 to 61 m). Uses: Quarried at Hagersville, Cayuga, and Port Colborne for crushed stone. High cherty content makes much of the material unsuitable for concrete aggregate. Los Angeles Abrasion Test: 14-28% loss; Soundness Test: 4-10% loss; Absorption: 0.7-2.0%.

Dundee Formation (Middle Devonian)

Composition: Fine- to medium-crystalline, brownish grey, medium- to thick-bedded, dolomitic limestone with shaly partings, sandy layers, and chert in some areas. Thickness: 60 to 160 feet (18 to 49 m). Uses: Quarried near Port Dover and Pelee Island for crushed stone. Used at St. Marys as raw material for portland cement. Los Angeles Abrasion Test: 22-32% loss; Absorption: 0-4%.

Gull River Formation (Middle Ordovician)

Composition: Member A: thin- to thick-bedded, interbedded, grey argillaceous limestone and buff to green dolostone with a maximum thickness of 60 feet (18 m). Members B and C are dense, aphanitic limestones with argillaceous dolostone interbeds. Uses: Quarried at Kirkfield and Uhthoff for crushed stone. The product is generally fresh and compact with good cubic-shaped factor, low clay content, low absorption, and low soundness losses. Smooth particle surfaces may cause adhesion problems for asphalt. There is some alkali reactivity in a few of the layers.

Lockport and Amabel Formations (Middle Silurian)

Composition: Amabel Formation (Waterdown to the Bruce Peninsula): massive, fine-crystalline dolostone, with reef facies dolostone near Georgetown. Lockport Formation (lateral facies equivalent to the Amabel Formation from Waterdown to Niagara Falls): thin- to massive- bedded, fine-to medium-grained dolostone. Thickness: Amabel Formation: maximum observed

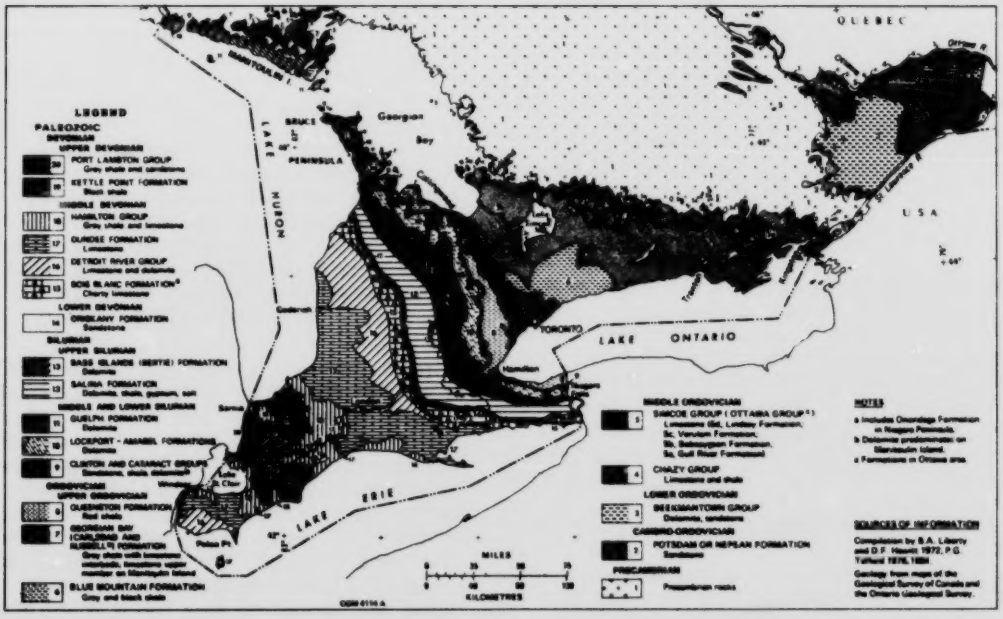


Figure 3. Bedrock Geology of Southern Ontario.

thickness of 84 feet (26 m). Lockport Formation: up to 130 feet (40 m). Uses: The Lockport and Amabel Formations have been used to produce lime, crushed stone, concrete aggregate and building stone throughout their area of occurrence, and are a resource of provincial significance. Los Angeles Abrasion Test: 21-35% loss; Soundness Test: 2.0% loss; Absorption: 0.4-1.6%.

Onondaga Formation (Middle Devonian)

(Equivalent to the Detroit River Group, with a textural change) Composition: Edgecliff Member: medium-bedded, fine- to medium- grained, dark grey cherty limestone with an estimated thickness of 25 to 30 feet (8 to 9 m). Clarence Member: massive-bedded, dark grey- brown, fine-grained, very cherty limestone having estimated thickness of 26 feet (8 m). Moorehouse Member: medium-bedded, dark grey-brown or purplish brown, fine- to coarse-grained, variably cherty limestone with an estimated thickness of 15 to 25 feet (5 to 8 m). Uses: Quarried for crushed stone on the Niagara Peninsula at Welland and Port Colborne. High cherty content makes much of the material unsuitable for concrete aggregate.

Ottawa Formation (Middle Ordovician)

Composition: Lower Phase (Lowville and Pamela Beds): shale, some sandstone and dolostone. Thickness: 100 feet (30 m). Middle Phase (Hull, Rockland, and Leray Beds): pure, thick-bedded, crystalline limestone. Thickness: 150 feet (46 m) near Ottawa. Upper Phase (Cobourg and Sherman Fall Beds): pure and impure crystalline limestone with few to numerous shaly partings, 450 to 475 feet (137 to 145 m) thick near Ottawa. Uses: The Leray, Rockland, and Hull Beds have been quarried extensively for crushed stone and for building stone. In addition, the Hull Beds are an excellent source of limestone for cement production and agricultural uses.

Oxford Formation (Lower Ordovician)

Composition: Medium- to thick-bedded, grey dolostone, with some shaly partings. Thickness: 240 feet (73 m). Uses: Quarried for crushed stone (road and concrete aggregate) at Ottawa, Brockville, and Smiths Falls.

BEDROCK SUITABLE FOR LIME PRODUCTION AND OTHER CHEMICAL USES

Detroit River Group (Middle Devonian)

(Equivalent to the Onondaga Formation in the Niagara Peninsula, with a textural change) Composition: Near Beachville, the group consists of medium- to micro-crystalline, medium-bedded, high-purity limestone. It grades northwards near St. Marys to soft, evenly bedded, fine-grained dolostone with bituminous laminae. Massive, porous, reef facies material also occurs to the north (Formosa Reef Limestone). Thickness: 100 feet (30 m) at Beachville, 350 feet (107 m) at Clinton. Uses: The most important source of high-purity limestone in Ontario is the Lucas Formation of the Detroit River Group at Beachville. Detroit River limestone produces much of Ontario's lime and cement. The Anderdon Member of the Lucas Formation is quarried at Amherstburg for crushed stone.

Grenville Marble (Precambrian)

Composition: Recrystallized fine- to coarse-grained white limestone and dolostone, usually of high chemical purity. Uses: Lime production, but also in small amounts for terrazzo chips, poultry grit, decorative stone, and building stone.

Guelph Formation (Middle Silurian)

Composition: Aphanitic to medium-crystalline, thick-bedded, soft, porous dolostone, characterized in places by extensive vuggy, porous reefal facies dolostone of high chemical purity. Thickness: 100 to 170 feet (30 to 52 m). Uses: The main use is for dolomitic lime in the construction industry. The formation is quarried near Hamilton and Guelph.

Lindsay Formation (Upper Ordovician)

Composition: fine-crystalline, rubbly, nodular-weathering limestone. Collingwood Member: organic-rich interbedded calcareous shales and limestones. Uses: Quarried at Picton, Ogden Point and Bowmanville for cement. The formation is generally unsuitable for crushed stone, concrete aggregate, or granular base course.

Verulam Formation (Middle Ordovician)

Composition: Fossiliferous, pure to argillaceous limestone and interbedded calcareous shale. The rock is not resistant to erosion and commonly weathers to rubble. Thickness: 200 to 300 feet (61 to 91 m). Uses: Quarried at Picton, Ogden Point, and Mara Township for use in cement manufacture. The formation is unsuitable for crushed stone because of clay impurities, many clayey interbeds, and low abrasion resistance, high soundness losses and poor freeze and thaw resistance.

BEDROCK SUITABLE FOR BRICK AND TILE MANUFACTURE

Georgian Bay Formation (Upper Ordovician) (Formerly known as the Meaford-Dundas and Blue Mountain shales in the Toronto and Bruce Peninsula areas) Composition: Soft, fissile, blue-grey shale with limey or sandy lenses in a few places. Thickness: 640 feet (195 m) at Toronto. Uses: Several producers in the vicinity of Metro Toronto produce brick and structural tile. Lightweight aggregate has been produced at Streetsville by heat expansion of the shale.

Hamilton Group (Middle Devonian)

Composition: Grey shale with interbeds of crystalline and cherty limestone. The group has six formations, but only the Arkona Formation is of commercial value. It is a soft, light grey, calcareous shale which is plastic and easily worked when wet. Thickness: 80 to 300 feet (24 to 91 m). The Arkona Formation has a thickness of 14 to 121 feet (4 to 37 m). Uses: The Arkona Formation is extracted at Thedford and near Arkona for production of drainage tile.

Queenston Formation (Upper Ordovician)

Composition: Red, thin- to thick-bedded, sandy to argillaceous shale with green mottling and banding. Thickness: 400 to 500 feet (122 to 152 m). Uses: There are several large shale quarries developed in the Queenston Formation in the Toronto-Hamilton region and one at Russell, near Ottawa. All produce brick for construction. The Queenston Formation is the most important source material for brick manufacture in the Province.

BEDROCK SUITABLE FOR OTHER INDUSTRIAL PRODUCTS

Nepean (Potsdam) Formation (Cambro-Ordovician)

Composition: Creamy, coarse-grained, silica sandstone. Uses: Quarried throughout its area of outcrop for building stone, decorative stone, abrasives, and for glass making.

Salina Formation (Upper Silurian)

Composition: Grey and red shale, brown dolomite, and, in places, salt, anhydrite, and gypsum. The formation consists predominantly of evaporite deposits with up to eight members identified. Uses: Gypsum is mined at Hagersville, Caledonia, and Drumbo. Salt is mined at Goderich and is produced from brine wells at Amherstburg, Windsor, and Sarnia.

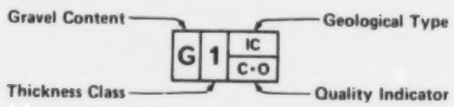
Blue Mountain Formation (Upper Ordovician)

(Formerly known as the Whitby Formation) Composition: Blue-grey, predominantly non-calcareous shale. Uses: Quarried at Bowmanville for use in cement production.

LEGEND

(continued from right margin)

DEPOSIT SYMBOL



Deposits are identified by Gravel Content, Thickness Class, Geological Type and Quality Indicator. Gravel Content is expressed as a percentage of gravel-sized material (i.e. material retained on the 4.75 mm sieve). Thickness Class is based on potential aggregate tonnage per acre. Geological Type refers to geologic origin. Quality Indicator describes objectionable grain size and lithology.

Gravel Content

G	Greater than 35% gravel.
S	Less than 35% gravel.

Thickness Class

Class	Average Thickness in Feet (Metres)	Tons per Acre	Tonnes per Hectare
1	greater than 20 (>6)	greater than 50,000	greater than 112 000
2	10 - 20 (3 - 6)	25,000 - 50,000	56 000 - 112 000
3	5 - 10 (1.5 - 3)	12,500 - 25,000	28 000 - 56 000
4	less than 5 (<1.5)	less than 12,500	less than 28 000

Geological Type

AL	Older Alluvium	**K**	Kame
E	Esker	**LB**	Lacustrine Beach
EM	End Moraine	**LD**	Lacustrine Delta
IC	Undifferentiated Ice-Contact Stratified Drift	**LP**	Lacustrine Plain
		OW	Outwash
ICT	Ice-Contact Terrace	**WD**	Windblown Forms

(see Appendix C for descriptions of Geological Types)

Quality Indicator

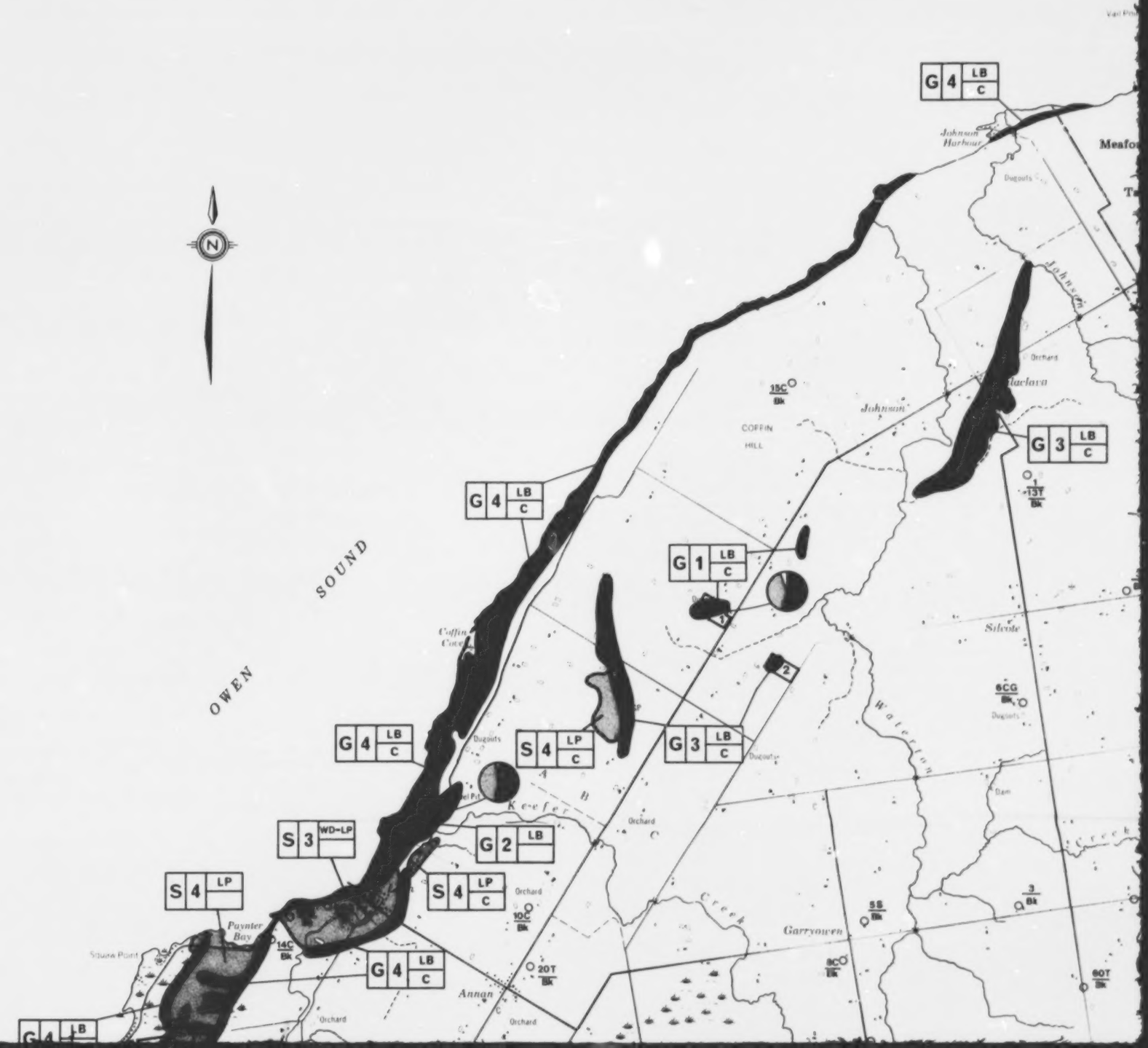
	If blank, no known limitations present.
C	Clay and/or silt (fines) present in objectionable quantities.
L	Deleterious lithologies present.
O	Oversize particles or fragments present in objectionable quantities.

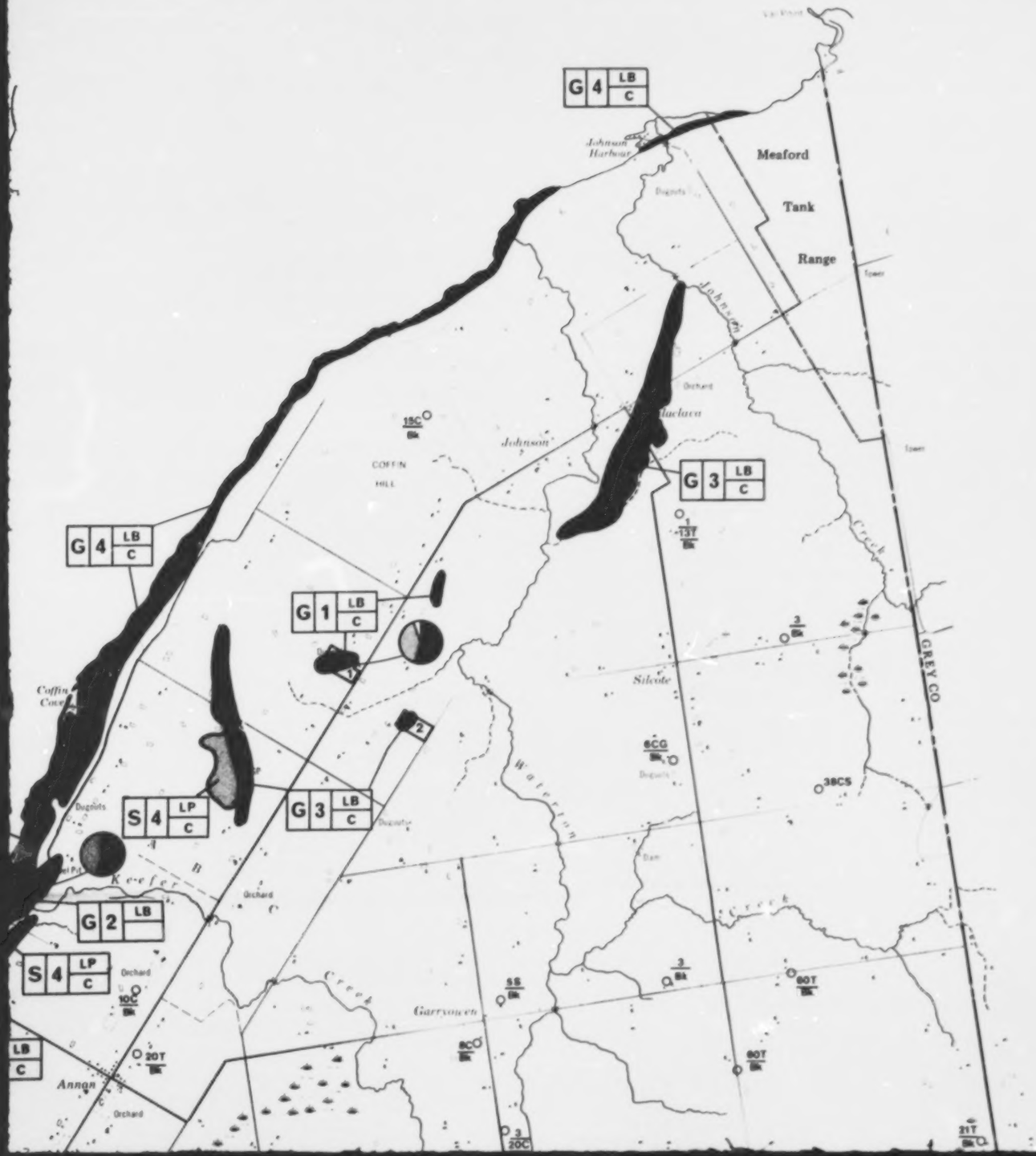
SOURCES OF INFORMATION

Base map by Surveys and Mapping Branch, Ontario Ministry of Natural Resources.

Licence data from District and Regional Offices, Ontario Ministry of Natural Resources.

Aggregate suitability data from the Engineering Materials Office, Ontario Ministry of Transportation and Communications.





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Minister

Mary Mogford
Deputy Minister

Ontario

ONTARIO GEOLOGICAL SURVEY

AGGREGATE RESOURCES INVENTORY

SYDENHAM TOWNSHIP

GREY COUNTY

MAP 1
DISTRIBUTION OF SAND AND GRAVEL DEPOSITS

Scale 1: 50 000

Mile 1 0 1 Mile

Metres 10000 0 1 Kilometre

NTS Reference: 41 A/7, 41 A/10

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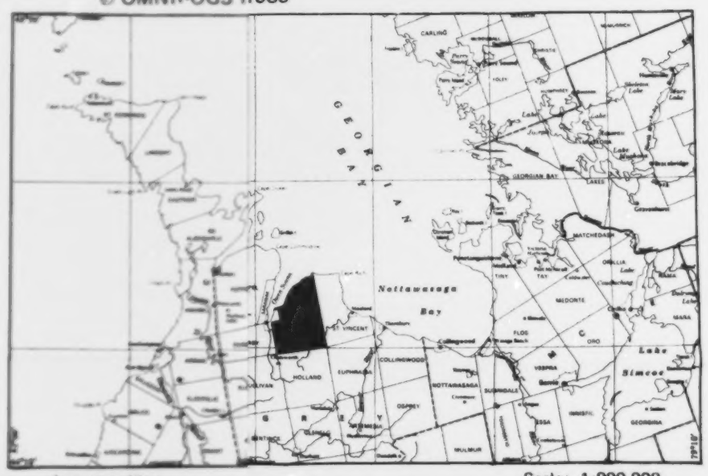


Location Map

Scale: 1:800,000

LEGEND

(Some map units and symbols may not apply to this map.)

MAP UNITS

Gravel deposit.

Class	Average Thickness in Feet (Metres)	Tons per Acre	Tonnes per Hectare
1	greater than 20 (>6)	greater than 50,000	greater than 112 000
2	10 - 20 (3 - 6)	25,000 - 50,000	56 000 - 112 000
3	5 - 10 (1.5 - 3)	12,500 - 25,000	28 000 - 56 000
4	less than 5 (<1.5)	less than 12,500	less than 28 000

Geological Type

AL	Older Alluvium	K	Kame
E	Esker	LB	Lacustrine Beach
EM	End Moraine	LD	Lacustrine Delta
IC	Undifferentiated Ice-Contact Stratified Drift	LP	Lacustrine Plain
		OW	Outwash
ICT	Ice-Contact Terrace	WD	Windblown Forms

(see Appendix C for descriptions of Geological Types)

Quality Indicator

If blank, no known limitations present.

C	Clay and/or silt (fines) present in objectionable quantities.
L	Deleterious lithologies present.
O	Oversize particles or fragments present in objectionable quantities.

SOURCES OF INFORMATION

Base map by Surveys and Mapping Branch, Ontario Ministry of Natural Resources.

Licence data from District and Regional Offices, Ontario Ministry of Natural Resources.

Aggregate suitability data from the Engineering Materials Office, Ontario Ministry of Transportation and Communications.

Test hole data from Aggregate Assessment Office, Ontario Geological Survey, Ontario Ministry of Natural Resources.

Selected water well data from the Ontario Ministry of the Environment.

Drilling data from the Petroleum Resources Section, Ontario Ministry of Natural Resources.

Geology by: B. H. Feenstra, in prep.

Additional Field Work by: Staff of the Aggregate Assessment Office.

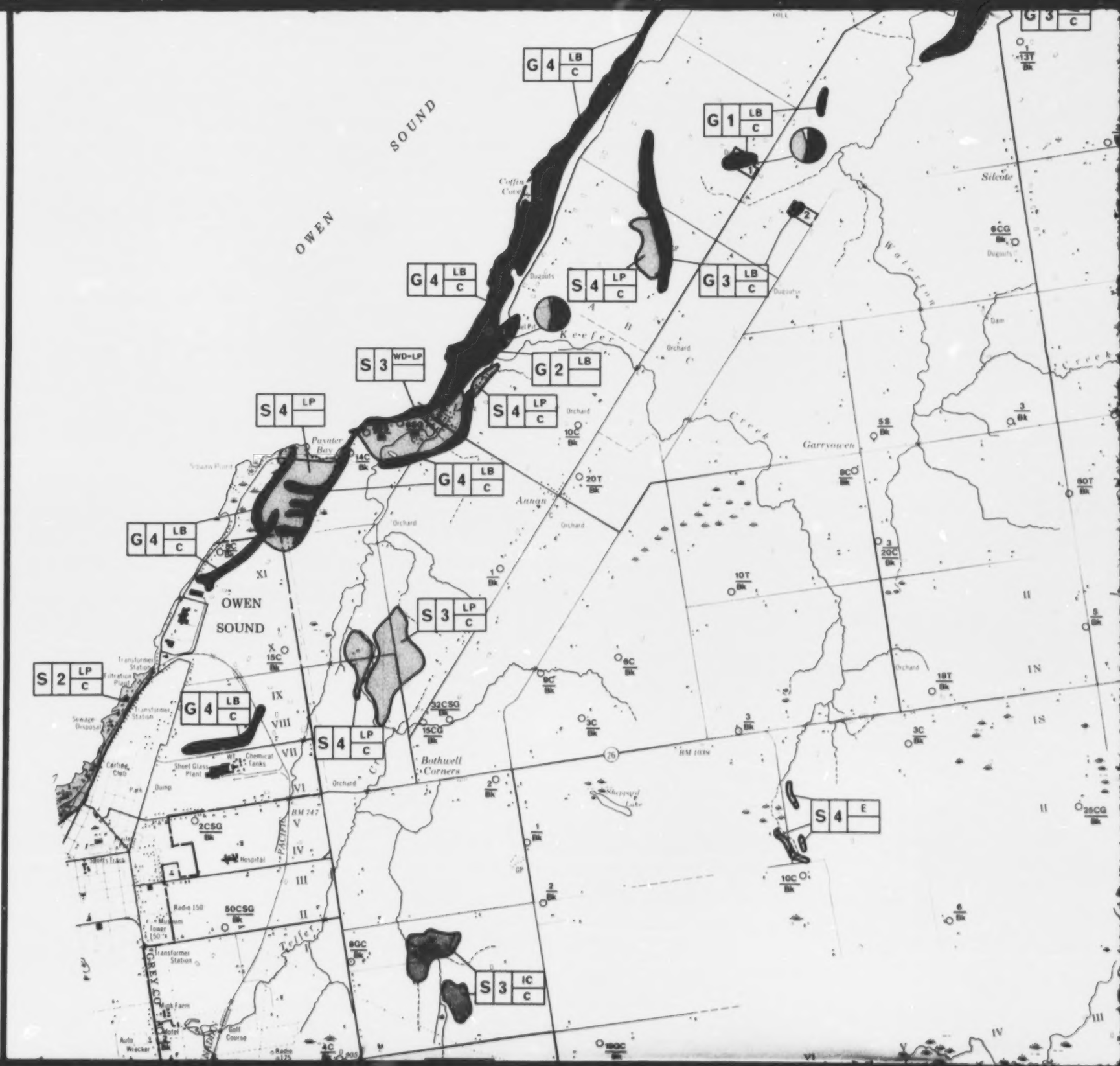
Compilation and Drafting by: Staff of the Aggregate Assessment Office.

This map is to accompany O.G.S. Aggregate Resources Inventory Paper 118.

This map is published with the permission of V. G. Milne, Director, Ontario Geological Survey.

Issued 1985.

Information quoted for an individual test hole or pit refers to a specific sample or face. Care should be exercised in extrapolating such information to other parts of the deposit.



Mile 1 0 1 Mile

Metres 1000 0 1 Kilometre

NTS Reference: 41 A/7, 41 A/10

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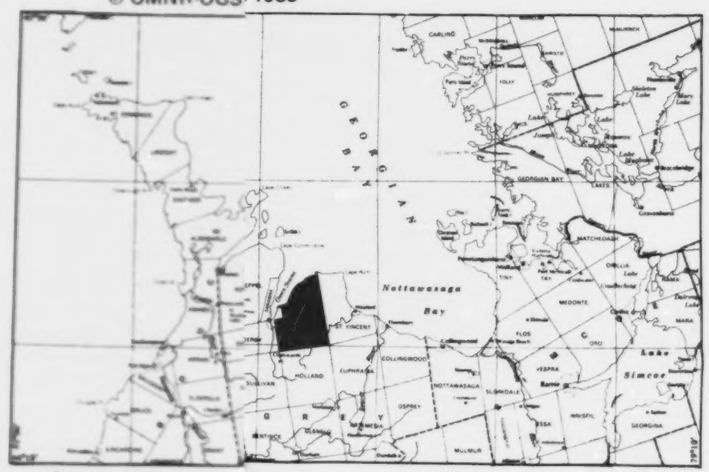


Scale: 1:800,000

LEGEND

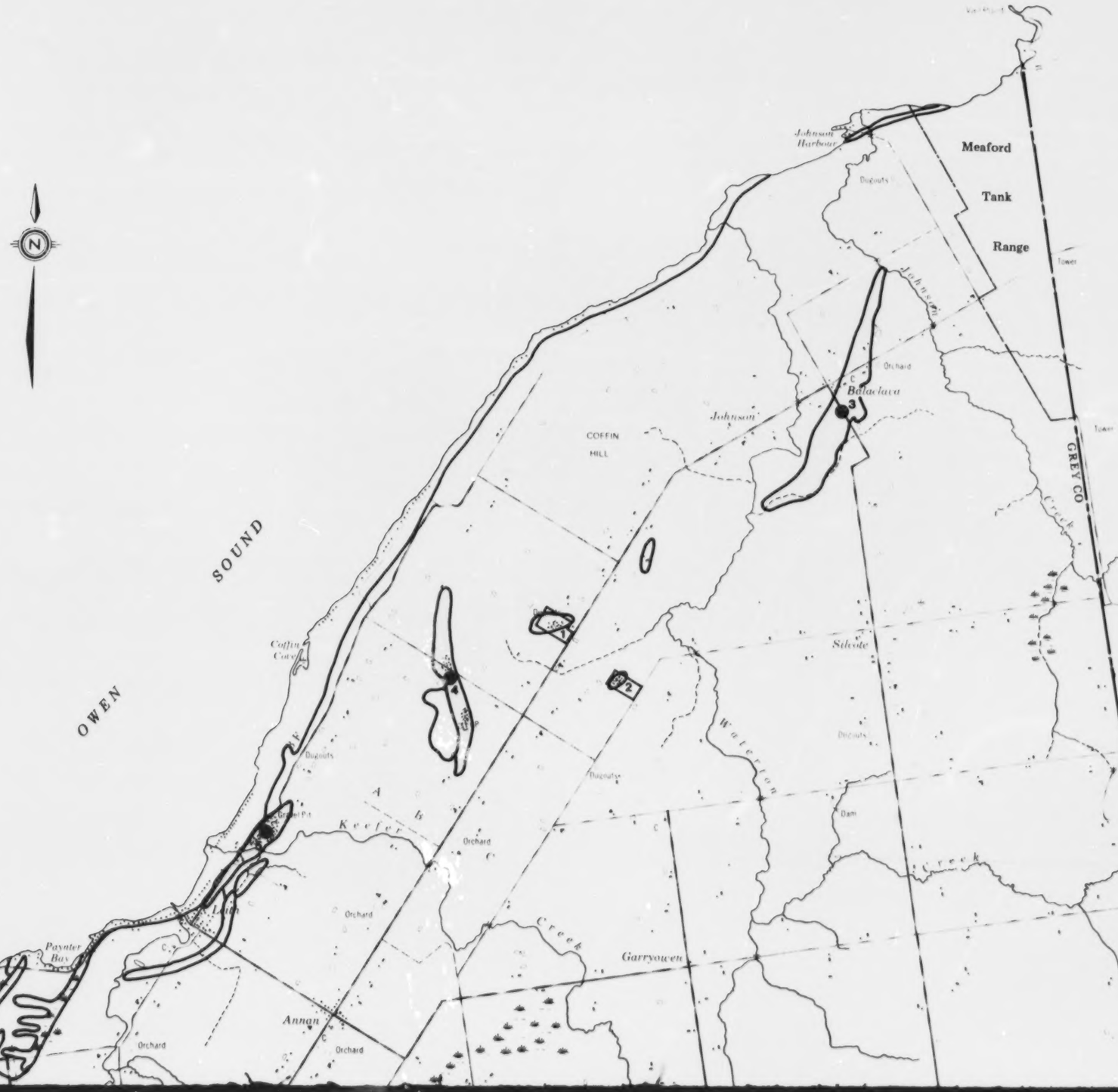
(Some map units and symbols may not apply to this map.)

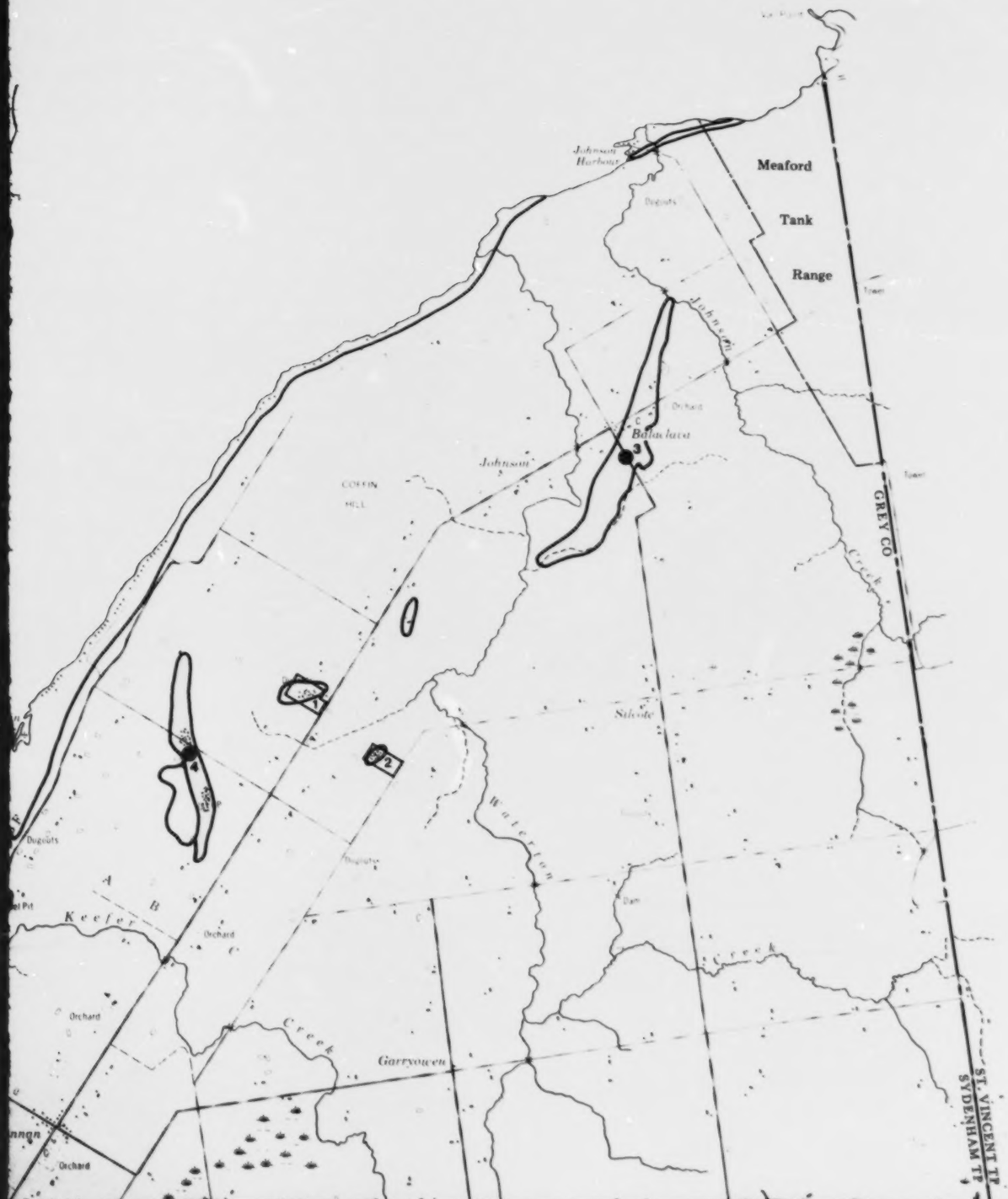
MAP UNITS

- Gravel deposit.
- Sand deposit.
- Gravel overlain by other surficial material.
- Sand overlain by other surficial material.
- Other surficial deposits or exposed bedrock.

SYMBOLS

- Geological and aggregate thickness boundary of sand and gravel deposits.
- Municipal boundary.
- 2 — Licenced property boundary; Property number: see Table 2.
- 3 — Unlicenced sand or gravel pit*; Property number: see Table 2. *Abandoned pit or wayside pit operating on demand under authority of a permit.
- SD-TH-2 — Test hole location: identification number; see Table 7.
- Selected water well location. Layers of materials are described by: reported thickness of material (in feet); reported type of material (number only - overburden, G - gravel, S - sand, C - clay, T - till, B - boulders, Bk - bedrock).
- G 1 LB C-O — Deposit symbol; see left margin.


N
OWEN SOUND
Johnson Harbour
Meaford
Tank
Range
Tower
Dugouts
Johnson
Orchard
Balaclava
COFFIN HILL
GREY CO
Coffin Cave
Silcote
Waterton
Dam
Creek
Keefer
Garryowen
Payster Bay
Annan
ST. VINCENT TP
SAUBNHAM TP



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Ontario

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Minister

Mary Mogford
Deputy Minister

ONTARIO GEOLOGICAL SURVEY

AGGREGATE RESOURCES INVENTORY

SYDENHAM TOWNSHIP

GREY COUNTY

MAP 2
SELECTED SAND AND GRAVEL RESOURCE AREAS

Scale 1: 50 000

Mile 1 0 1 Mile

Metres 1000 0 1 Kilometre

NTS Reference: 41 A/7, 41 A/10

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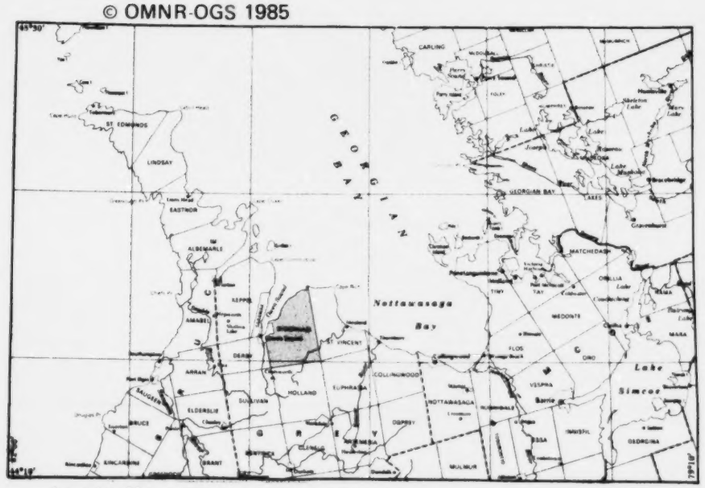

Location Map

Scale: 1:800,000

LEGEND

(Some map units and symbols may not apply to this map.)

MAP UNITS

Selected sand and gravel resource area, primary significance; deposit number; see Table 3.

GEORGIAN BAY
FORMATION
Johnson
Harbour
Tower
Tower
OWEN
SOUND
Coffin
Cove
BP
Gravel Pit
Pavnter
Bay
Squaw Point
Garryowen
1f
AMABEL & FOSSIL HILL
FORMATIONS
CABOT HEAD &
MANITOULIN
FORMATIONS

Ministry of Natural Resources
Ontario

Hon. Michael Harris
Minister

Mary Mogford
Deputy Minister

ONTARIO GEOLOGICAL SURVEY

AGGREGATE RESOURCES INVENTORY

SYDENHAM TOWNSHIP

GREY COUNTY

MAP 3
BEDROCK RESOURCES

Scale 1: 50 000

Mile 1 0 1 Mile

Metres 1000 0 1 Kilometre

NTS Reference: 41 A/7, 41 A/10

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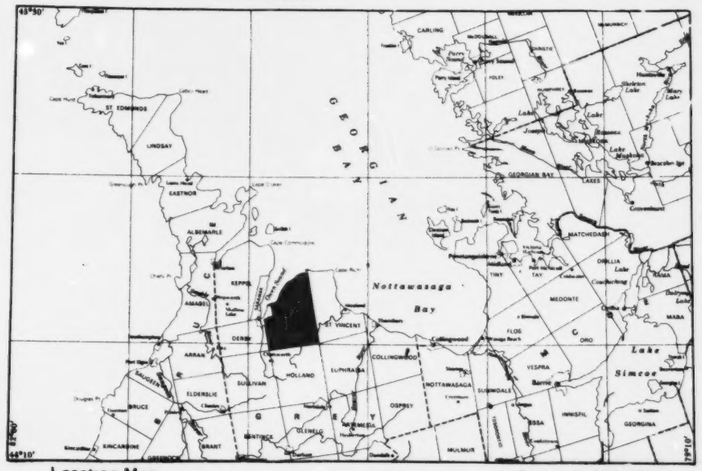

Location Map

Scale: 1:800,000

LEGEND

(Some units and symbols may not apply to this map.)

BEDROCK UNITS

PALEOZOIC

SILURIAN

MIDDLE SILURIAN

GUELPH FORMATION
Dolostone

AMABEL FORMATION
Dolostone

This map is to accompany O.G.S. Aggregate Resources Inventory Paper 118.

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Issued 1985.

Information quoted for an individual test hole or pit refers to a specific sample or face. Care should be exercised in extrapolating such information to other parts of the deposit.

SYDENHAM

SYMBOLS

Geological and gravel — Total and aggregate thickness boundary of sand and gravel deposits.

Municipal — Municipal boundary.

2 — Licenced property boundary; Property number: see Table 2.

3 — Unlicenced sand or gravel pit*; Property number: see Table 2.
*Abandoned pit or wayside pit operating on demand under authority of a permit.

SD-TH-2 — Test hole location; identification number; see Table 7.

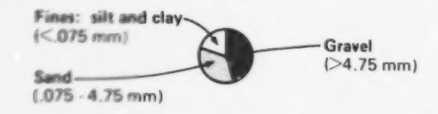
6 / 24G — Selected water well location. Layers of materials are described by: reported thickness of material (in feet); reported type of material (number only - overburden, G- gravel, S - sand, C - clay, T - till, B - boulders, Bk - bedrock).

G 1 IC C-O — Deposit symbol; see left margin.

Texture symbol; see below; see Figures 2a & 2b.

SD-GT-2 — Geophysical traverse line; Identification number.

TEXTURE SYMBOL



The Texture Symbol provides quantitative assessment of the grain size distribution at a sampled location. The relative amounts of gravel, sand, silt and clay in the sampled material are shown graphically by the subdivision of a circle into proportional segments. The above example shows a hypothetical sample consisting of 45% gravel, 35% sand and 20% silt and clay.

(continued at left margin)

OWEN

OWEN SOUND

ST. VINCENT TP
SYDENHAM TP

GREY CO

GREY CO

Bothwell Corners

Keefer

Annan

Garvocaven

Woodford

Silcote

Pamlet Bay

Sharpe Lake

Airfield

Golf Course

Mink Farm

Motel

Auto Wrecker

Radio 150

Radio 175

Museum Tower 150

Transformer Station

Hospital

Dump

Chemical Tanks

Sheet Glass Plant

Yacht Club

Orchard

Dwellings

Dam

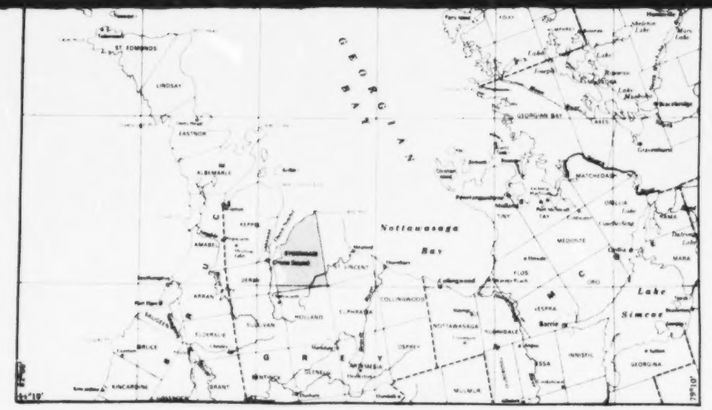
2 Lines

RM 747

RM 1039

GP

I
II
III
IV
V
VI
VII
VIII
IX
X
XI
XII



Location Map

Scale: 1:800,000

LEGEND

(Some map units and symbols may not apply to this map.)

MAP UNITS

(1)	Selected sand and gravel resource area, primary significance; deposit number; see Table 3.
	Selected sand and gravel resource area, secondary significance.
	Selected sand and gravel resource area, tertiary significance.

SYMBOLS

———	Geological and aggregate thickness boundary of sand and gravel deposits.
—— - ——	Municipal boundary
2	Licenced property boundary; Property number: see Table 2.
● 3	Unlicenced sand or gravel pit*; Property number: see Table 2. *Abandoned pit or wayside pit operating on demand under authority of a permit.

SOURCES OF INFORMATION

Base map by Surveys and Mapping Branch, Ontario Ministry of Natural Resources.

Licence data from District and Regional Offices, Ontario Ministry of Natural Resources.

Aggregate suitability data from the Engineering Materials Office, Ontario Ministry of Transportation and Communications.

Geology by: B. H. Feenstra, in prep.

Additional Field Work by: Staff of the Aggregate Assessment Office.

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OWEN

Coffin Cove

BF

Dugouts

Gravel Pit

Keith

Paynter Bay

Garryowen

CABOT HEAD & MANITOULIN FORMATIONS

1f

AMABEL & FOSSIL HILL FORMATIONS

Transformer Station

Filtration Plant

Sewage Disposal

Chemical Tanks

Orchard

Bowyer Creek

BM 747

PACIFIC

Hospital

CABOT HEAD & MANITOULIN FORMATIONS

Telfer

Auto Wrecker

2b

CABOT HEAD & MANITOULIN FORMATIONS

Dam

2 Lines

QUEENSTON FORMATION

Loca

BED

DRIF

SYMB

Location Map

Scale: 1:800,000

LEGEND

(Some units and symbols may not apply to this map.)

BEDROCK UNITS

PALEOZOIC

SILURIAN

MIDDLE SILURIAN

GUELPH FORMATION
Dolostone

AMABEL FORMATION
Dolostone

FOSSIL HILL FORMATION
Dolostone

LOWER SILURIAN

CABOT HEAD FORMATION
Shale

MANITOULIN FORMATION
Dolostone

ORDOVICIAN

UPPER ORDOVICIAN

QUEENSTON FORMATION
Red shale

GEORGIAN BAY FORMATION
Grey shale and limestone interbeds

DRIFT THICKNESS

Bedrock outcrop (see Table 4); areas of exposed bedrock partially covered by a thin veneer of drift. Drift thickness is generally less than 3 feet (1 m).

Bedrock covered by drift (see Table 4); drift thickness is generally 3 to 25 feet (1 to 8 m). Bedrock outcrops may occur.

Bedrock covered by drift (see Table 4); drift thickness is generally 25 to 50 feet (8 to 15 m). Isolated bedrock outcrops may occur.

Bedrock covered by drift; drift thickness is generally greater than 50 feet (15 m).

SYMBOLS

1 — Selected bedrock resource area; deposit number; see Table 6.

Geological formation boundary.

Geological formation member boundary.

Formation thickness boundary (see text).

25 — Drift thickness contour. (3-foot, 25-foot and 50-foot contours are shown).

Municipal boundary.

Q2 — Licenced quarry boundary; Property number: see Table 5.

Bothwell Corners
GREY CO
SYDENHAM TP
DERBY TP
Rockford
Heath Head
Autfield
North Spey River
Dugouts
McGill Lake
Walters Falls
SYDENHAM TP
HOLLAND TP
GREY CO
Dam
I
II
III
IV
V
VI
VII
VIII
IX
X
XI
XII

SYDENHAM

SYDENHAM

2 Licenced property boundary; Property number: see Table 2.

● 3 Unlicenced sand or gravel pit*; Property number: see Table 2.
*Abandoned pit or wayside pit operating on demand under authority of a permit.

SOURCES OF INFORMATION

Base map by Surveys and Mapping Branch, Ontario Ministry of Natural Resources.

Licence data from District and Regional Offices, Ontario Ministry of Natural Resources.

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Geology by: B. H. Feenstra, in prep.

Additional Field Work by: Staff of the Aggregate Assessment Office.

Compilation and Drafting by: Staff of the Aggregate Assessment Office.

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CABOT HEAD & MANITOULIN FORMATIONS

CABOT HEAD & MANITOULIN FORMATIONS II

AMABEL & FOSSIL HILL FORMATIONS

CABOT HEAD & MANITOULIN FORMATIONS

QUEENSTON FORMATION

CABOT HEAD & MANITOULIN FORMATIONS

CABOT HEAD & MANITOULIN FORMATIONS

GUELPH FORMATION

AMABEL & FOSSIL HILL FORMATIONS

SYDENHAM

DRIFT

SYMBO

Base map
sources
Licence d
Resour
Aggregate
Ministr
Selected
Drilling d
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Geology b

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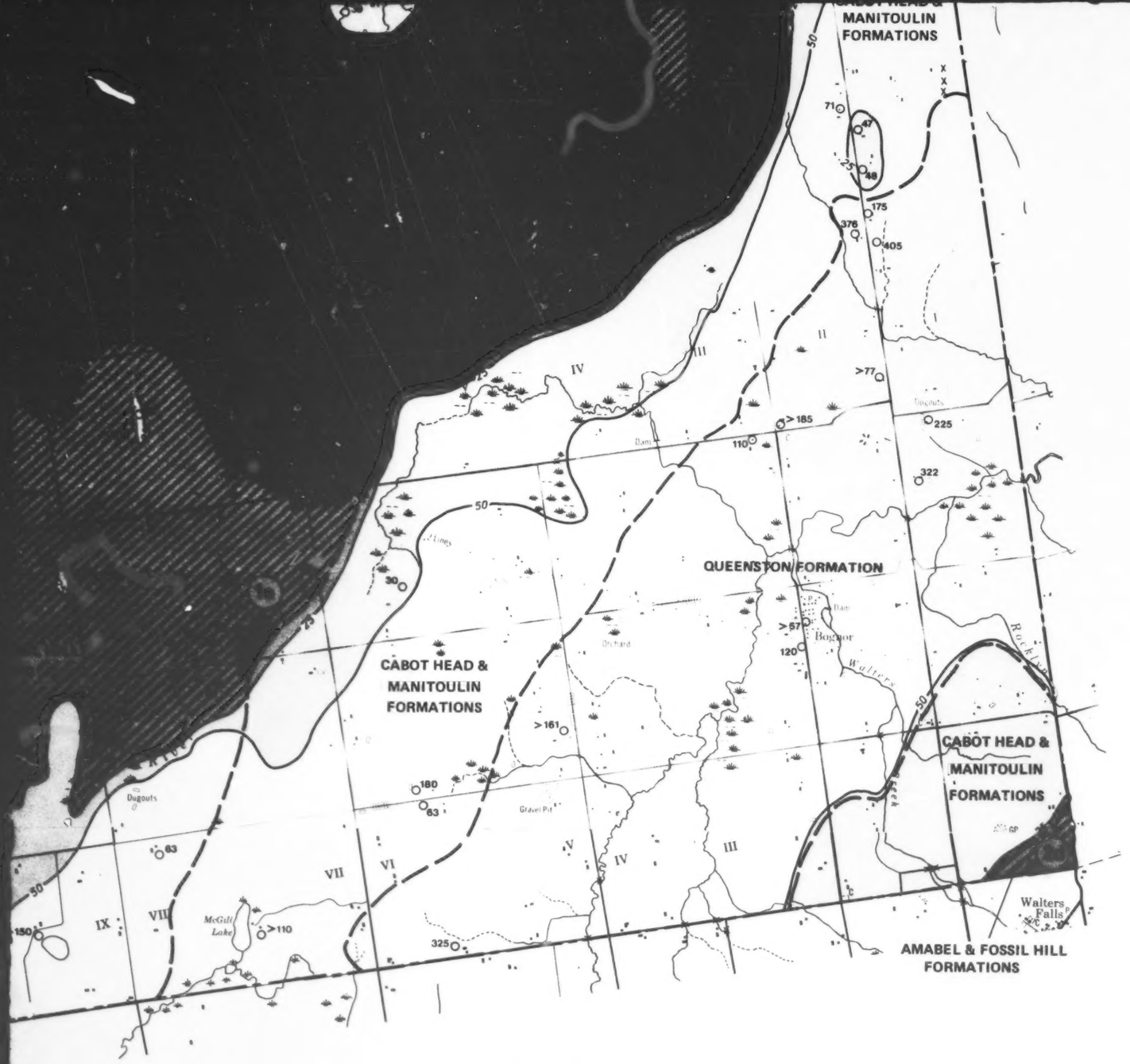
Issued 19



DRIFT THICKNESS

Bedrock outcrop (see Table 4); areas of exposed bedrock partially covered by a thin veneer of drift. Drift thickness is generally less than 3 feet (1 m).

Bedrock covered by drift (see Table 4); drift thickness is generally 3 to 25 feet (1 to 8 m). Bedrock outcrops may occur.

Bedrock covered by drift (see Table 4); drift thickness is generally 25 to 50 feet (8 to 15 m). Isolated bedrock outcrops may occur.

Bedrock covered by drift; drift thickness is generally greater than 50 feet (15 m).

SYMBOLS

(1) Selected bedrock resource area; deposit number; see Table 6.

Geological formation boundary.

Geological formation member boundary.

Formation thickness boundary (see text).

25 Drift thickness contour. (3-foot, 25-foot and 50-foot contours are shown).

Municipal boundary.

Q2 Licenced quarry boundary; Property number: see Table 5.

Q3 Unlicenced quarry*; Property number: see Table 5. *Abandoned quarry or wayside quarry operating on demand under authority of a permit.

x Isolated bedrock outcrop.

O 24 Selected water well location; reported depth to bedrock (in feet).

SOURCES OF INFORMATION

Base map by Surveys and Mapping Branch, Ontario Ministry of Natural Resources.

Licence data from District and Regional Offices, Ontario Ministry of Natural Resources.

Aggregate suitability data from the Engineering Materials Office, Ontario Ministry of Transportation and Communications.

Selected water well data from the Ontario Ministry of the Environment.

Drilling data from the Petroleum Resources Section, Ontario Ministry of Natural Resources.

Geology by: B. H. Feenstra, in prep.
B. A. Liberty, 1966.
B. A. Liberty and T. E. Bolton, 1971.

Compilation and Drafting by: Staff of the Aggregate Assessment Office.

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